

**The role of community-led innovation in the adaptive  
capacity of ecosystem services in an urban social-ecological  
system**

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## Table of Contents

List of Figures.....	v
List of Tables.....	ix
List of abbreviations used in this thesis.....	xi
Glossary of terms.....	xii
Acknowledgements.....	xv
Abstract.....	xvi
Chapter One: Introduction.....	1
1.1 The conurbation of Greater Manchester as a modern social-ecological system.....	3
1.2 The modern social-ecological Landscape.....	9
Chapter Two: Literature Review.....	12
2.1 Social-ecological memory, learning and innovation: teaching a new dog old tricks?.....	12
2.2 Defining social-ecological innovation.....	13
2.3 Understanding and management in social-ecological systems.....	14
2.4 The rise of the ecological citizen.....	30
2.5 The ecology of urban areas.....	32
2.6 The reciprocity of human and environmental health in urban areas.....	34
2.7 Environmental accounting and applying the ecosystem approach in the UK.....	35
2.8 Applying resilience theory to ecosystem services management.....	37
2.9 Modern social-ecological challenges and urban areas.....	42
2.10 Food and the environment: an uncomfortable relationship.....	44
2.11 Urban agriculture – a response to local and global stresses.....	46
2.12 The potential for self-producing urban areas.....	47
2.13 Aims and objectives.....	50
2.13.1 Theoretical perspectives.....	50
2.13.2 Research aims.....	51
2.13.3 Objectives.....	51
Chapter Three: Research Methodology.....	53
3.1 Theoretical framework.....	53
3.2 Research overview.....	54
3.3 Justification of the case study approach.....	59

Chapter Four: Mapping Organised Social-ecological Innovation .....	64
4.0 Introduction .....	64
4.1 Methods .....	64
4.1.1 Spatial distribution of OSEIs .....	66
4.1.2 Analysis of demographic characteristics .....	66
4.1.3 Analysis of physical (land-cover) characteristics .....	67
4.1.4 Socio-economic analysis .....	69
4.1.5 Analysis of the spatial distribution of types of OSEI .....	70
4.2 Mapping exercise: results.....	71
4.2.1 Types of social-ecological Innovation .....	71
4.2.2 Demographic analysis .....	75
4.2.3 Land-cover analysis.....	81
4.2.4 Socio-economic analysis .....	90
4.2.5 Integrated analysis of total environmental and socio-economic factors.....	97
4.2.6 Distribution of OSEI according to type .....	98
4.2.7 Dynamics of social-ecological deprivation. ....	106
4.3 Discussion of the mapping exercise .....	113
4.3.1 Social-ecological innovation and urban agriculture .....	113
4.3.2 Locations of OSEIs.....	114
4.3.4 Types of organised social-ecological innovation in the urban landscape .....	117
4.4 Conclusions of the mapping exercise .....	120
4.4.1 The urban context of organised social-ecological innovation.....	120
4.4.2 Urban fabric complexity and adaptability in organised social-ecological innovation	121
4.4.3 Social-ecological networks: distribution and thresholds in organised social-ecological Innovation.....	122
4.4.4 OSEI as an adaptive response to local social-ecological conditions.....	127
4.4.5 Defining networks in social-ecological innovation .....	129
Chapter Five: Case-study of Sites of Organised Social-ecological Innovation .....	135
5.0 Introduction: case-study approach .....	135
5.1 Case study site selection .....	136
5.1.1 Community gardens.....	137
5.1.2 Community allotments .....	138

5.1.3	Community orchards .....	139
5.1.4	Pocket parks.....	140
5.1.5	Ecosystem services selected for study .....	143
5.2	Data collection methods .....	144
5.2.1	Microclimate regulation .....	144
5.2.2	Food production .....	151
5.2.3	Biodiversity potential.....	152
5.2.4	Education and well-being .....	155
5.2.5	Site access and setting.....	156
5.2.6	Presentation of data .....	157
5.3	Case study results.....	157
5.3.1	Case study site descriptions: initial surveys .....	160
5.3.1.1	OSEI type descriptions: community gardens.....	185
5.3.1.2	Community allotments .....	186
5.3.1.3	Community orchards .....	188
5.3.1.4	Pocket parks.....	188
5.3.2	Ecosystem services: microclimate regulation.....	189
5.3.3	Food production .....	192
5.3.4	Biodiversity potential.....	196
5.3.5	Education and well-being .....	200
5.4	Discussion .....	206
5.4.1	Microclimate regulation .....	206
5.4.2	Food production .....	208
5.4.3	Biodiversity potential.....	209
5.4.4	Education and well-being .....	212
5.4.5	Variation observed in service provision .....	215
5.4.6	Relative social-ecological impact of case study sites .....	216
5.4.7	Summarizing type characteristics.....	218
Chapter Six: Valuation, trade-offs and synergies of Ecosystem Service Provision .....		220
6.0	Introduction.....	220
6.1	Methods .....	221
6.1.1	Monetary valuation of services from OSEI.....	224

6.1.2	Provision of ecosystem services, synergies and trade-offs .....	228
6.1.3	Evaluating synergies and trade-offs .....	228
6.2	Results .....	230
6.2.1	Estimating the value of organised social-ecological innovation in Manchester, Salford and Trafford.....	230
6.2.2	Site contributions to service provision.....	231
6.2.3	Measures of site provision per unit area.....	233
6.2.4	Ecosystem service synergies and trade-offs.....	235
6.3	Discussion of ecosystem service provision by organised social-ecological innovation ..	244
6.3.1	Extent of service provision by OSEI in urban areas .....	244
6.3.2	Trade-offs and synergies in ecosystem service provision .....	246
6.3.3	Site characteristics and service provision.....	247
6.3.4	Independence of service provision.....	250
6.3.5	The centrality of food for social-ecological innovation in the urban landscape .....	252
	Chapter Seven: Summary .....	255
7.1	Assessing the value of social-ecological innovation in the urban landscape.....	255
7.2	Biodiversity and social-ecological intensification by OSEI .....	256
7.3	Site design considerations in multi-functional urban micro-scapes .....	257
7.4	The efficacy of food as a foundation for social-ecological intensification.....	259
7.5	The role of social-ecological innovation for resilience building in urban areas.....	261
7.6	Recommendations and scope for future research: harnessing the potential of social-ecological innovation towards more self-productive, resilient towns and cities .....	265
7.6.1	Learning from OSEI design towards an approach to best practice .....	266
7.6.2	Considerations relating to the standardising of innovation.....	269
7.7	Concluding Remarks .....	271
	Appendices .....	277

## List of Figures

Figure 1.1	Study area with administrative boundaries (lower super output areas) and Manchester city centre (ONS, 2011). .....	6
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Figure 1.2 Study area most representative MOSAIC group by LSOA (ONS, 2001).....	8
Figure 2.1 The four phases of the adaptive cycle in social-ecological systems (Gunderson and Holling, 2002).....	17
Figure 2.2 Adaptive cycle and associated "traps" (adapted from Biggs et al., 2010). .....	19
Figure 2.3 Social-ecological systems panarchy (Gunderson and Holling, 2002). .....	21
Figure 2.4 Millennium Ecosystem Assessment of services to well-being (2005).....	26
Figure 2.5 Cycles and drivers of change in ecosystem services (MEA, 2005). .....	27
Figure 2.6 Interconnectedness of social-ecological conditions, resilience and ecosystem services in sustainable social-ecological systems.....	40
Figure 2.7 Negative feedbacks in resilience, ecosystem services and social-ecological systems. ....	41
Figure 3.1 Research Overview .....	61
Figure 3.2 Relationship between research elements in this thesis.....	63
Figure 4.1 Distribution of organised social-ecological innovation across the three districts in the study area (ONS, 2011). .....	75
Figure 4.2 Site occurrence by district. ....	76
Figure 4.3 OSEIs within 5km radius of Manchester city centre (ONS, 2011). .....	77
Figure 4.4 Population distribution by lower super output area (ONS, 2011). .....	78
Figure 4.5 LSOA ethnic group population (Group 0 = OSEI not found; Group 1 = OSEI found). .....	80
Figure 4.6 OSEI distribution and normalised difference vegetation index (ONS, 2001; NASA, 2013).....	82
Figure 4.7 Study area surface sealing density ( $m^2\ 1000m^{-2}$ ) by LSOA (ONS, 2001).....	84
Figure 4.8 Study area buildings cover density ( $m^2\ 1000m^{-2}$ ) by LSOA (ONS, 2001). .....	86
Figure 4.9 Study area green space density ( $m^2\ 1000m^{-2}$ ) per LSOA (ONS, 2001). .....	88
Figure 4.10 Study area domestic gardens cover ( $m^2\ 1000m^{-2}$ ) per LSOA (ONS, 2001). .....	89
Figure 4.11 MOSAIC classification data: most representative category by LSOA (ONS, 2001). .....	91

Figure 4.12 Most represented MOSAIC households in LSOA Groups 0 (OSEI not found) and 1 (OSEI found).....	92
Figure 4.13 Organised social-ecological innovation and IMD scores by LSOA (ONS, 2001). ...	94
Figure 4.14 Change in UK IMD score in Group 0 ("no"), and Group 1 ("yes"). .....	95
Figure 4.15 Means plot for ANOVA model: mean surface sealing (as percentage). .....	100
Figure 4.16 Type locations: mean population densities. ....	102
Figure 4.17 Type mean health deprivation scores. ....	103
Figure 4.18. Type mean crime and disorder deprivation scores.....	104
Figure 4.19 OSEI type and degree of combined social-ecological deprivation.....	107
Figure 4.20 Mean deprivation percentile rank for OSEI type locations.....	109
Figure 4.21 Relative levels of social-ecological deprivation and types of OSEI (ONS, 2001). ..	111
Figure 4.22 Thresholds in the occurrence of OSEI. ....	124
Figure 4.23 Suggested model of social-ecological networks associated with OSEI. ....	131
Figure 5.1 Fallowfield Secret Garden community garden: growing area. (September 2013). .....	137
Figure 5.2 "Grow For It" community allotment, Chorlton. View towards Scott Avenue Allotments. (September 2013). ....	139
Figure 5.3 Philips Park Community orchard. View towards allotment site (September 2013). .....	140
Figure 5.4 Pocket park on Dale Street car park. View towards Northern Quarter (September 2013). ....	141
Figure 5.5 Location of case study sites (Google Earth, 2015). ....	142
Figure 5.6 Centenary Gardens schematic plan.....	161
Figure 5.7 Location of Centenary Gardens (Google Earth, 2015). ....	162
Figure 5.8 Fallowfield Secret Garden schematic plan. ....	163
Figure 5.9 Location of Fallowfield Secret Garden (Google Earth, 2015). ....	164
Figure 5.10 Barlow Moor road community garden schematic plan. ....	165
Figure 5.11 Location of Barlow Moor Road Community Garden (Google Earth, 2015). ....	166
Figure 5.12 Planting and Learning Old Trafford (PLOT) schematic plan. ....	167
Figure 5.13 Location of Planting and Learning Old Trafford (Google Earth, 2015). ....	168
Figure 5.14 Moss Side community allotment schematic plan. ....	169

Figure 5.15 Location of Moss Side Community Allotment (Google Earth, 2015). .....	170
Figure 5.16 Grow For It Chorlton schematic plan. ....	171
Figure 5.17. Location of "Grow For It", Chorlton (Google Earth, 2015). ....	172
Figure 5.18 Stenner Lane community orchard schematic plan.....	173
Figure 5.19 Location of Stenner Lane Community Orchard (Google Earth, 2014). ....	174
Figure 5.20. Birch Fields Forest Garden schematic plan. ....	175
Figure 5.21 Location of Birch Fields Forest Garden (Google Earth, 2015). ....	176
Figure 5.22 Philips Park community orchard schematic plan. ....	177
Figure 5.23 Location of Philips Park Community Orchard (Google Earth, 2014). ....	178
Figure 5.24 The Triangle schematic plan. ....	179
Figure 5.25 Location of The Triangle (Google Earth, 2014). ....	180
Figure 5.26. Dale Street car park site: schematic plan. ....	181
Figure 5.27. Location of Dale Street car park (Google Earth, 2014). ....	182
Figure 5.28 Hulme Community Garden Centre annexe: schematic plan.....	183
Figure 5.29 Location of Hulme Community Garden Centre annexe (Google Earth, 2015)....	184
Figure 5.30 Mean GI score by OSEI type.. ....	191
Figure 5.31 Mean extent of cultivation effort by type. ....	193
Figure 5. 32 Mean yield 100m by type. ....	195
Figure 5.33. Original biodiversity assessment scores: type means.....	199
Figure 5.34. Type mean BAR (biodiversity-area ratio 100m <sup>-2</sup> ).. ....	200
Figure 5.35 Community benefit factor 100m <sup>-2</sup> : type means. ....	204
Figure 6.1 Evaluating ecosystem service value, contributions and trade-offs: overview.....	223
Figure 6.2 Case study site cumulative provision score (gross) by ecosystem service. ....	232
Figure 6.3 OSEI type gross provision for case-study services.....	232
Figure 6.4 Contributions to case study cumulative provision score 100m <sup>-2</sup> .....	233
Figure 6.5 Type gross provision 100m <sup>-2</sup> for case study services. ....	234
Figure 6.6 OSEI type mean percentage contribution 100m <sup>-2</sup> spread by service.....	234
Figure 6.7 Volunteer effort: effect on site genera richness . ....	238
Figure 6.8 Regression of site volunteer effort against cumulative service provision score. ....	240
Figure 6.9 Effect of site size on ecosystem service productivity.....	241
Figure 6.10 Total site area and community benefit factor score.....	242



Figure 7. 1 Overview of OSEI-related feedbacks in sustainable urban social-ecological systems. ....	264
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## List of Tables

Table 2.1 Approaches to natural resource management.....	29
Table 3.1 Theoretical frameworks adopted in this thesis. ....	54
Table 4.1 Study area LSOA basic statistics (2001 - 2010 boundary data, ONS). ....	68
Table 4.2 Site categories.....	74
Table 4.3 Group comparison p-values (Mann-Whitney U-test) across IMD domains. ....	96
Table 4.4 Landscape parameter correlations. ....	97
Table 4.5 Binary logistic regression: ecological and socio-economic conditions as predictors of OSEI occurrence. ....	98
Table 4.6 Significant mean differences between OSEI type locations: proportion surface sealing. ....	101
Table 4.7 Type mean differences: population density. ....	102
Table 4.8 Significant mean differences between types: health deprivation. ....	104
Table 4.9 Significant mean differences between types: crime and disorder.....	105
Table 4.10 Discriminant function analysis: structure matrix. ....	106
Table 4.11 OSEI and study area comparison: descriptive statistics. ....	107
Table 4.12 OSEI type location social-ecological deprivation: descriptive statistics. ....	108
Table 5. 1 Biotope Area Factor weightings/descriptions. ....	147
Table 5.2 Worked example of BAF tool.....	148
Table 5. 3 Classification of vegetative structure Domin values in Tzoulas and James (2010). .....	153
Table 5. 4 Modification of biodiversity score according to built layer Domin value (Tzoulas and James, 2010). ....	154

Table 5. 5 Key and basic site information.....	159
Table 5.6 Case study site access. ....	185
Table 5.7 GI score by type. ....	190
Table 5.8 Food related practices and projected food yields. ....	192
Table 5.9 Yield per site as kg 100m <sup>-2</sup> . ....	194
Table 5.10 Biodiversity assessment data. ....	196
Table 5.11 Site biodiversity-area ratio scores. ....	198
Table 5. 12 Data related to education and well-being. ....	201
Table 5.13 Site Community Benefit Factor (CBF) scores 100m <sup>-2</sup> . ....	203
Table 5.14 Summary of variance in service assessment scores (as co-efficient of variation). .....	205
Table 5. 15 Equality in service provision (expressed as co-efficient of variation (cv), where a lower cv indicates greater evenness in provision across services). ....	205
Table 6.1 Local retail prices for fruit produce. ....	226
Table 6.2 Summary of monetary valuation of site service provision.....	230
Table 6.3 Correlations between services and overall (cumulative) provision. ....	235
Table 6.4 Site characteristic relationships.....	237
Table 6.5 Site attribute regression statistics. Dependent variable: cumulative provision score. .....	243
Table 7.1 Integrating OSEI into the landscape. ....	274
Table 7.2 Recommendations for Further Research. ....	276

## **List of abbreviations used in this thesis**

**ANOVA:** Analysis of variance

**CV:** Co-efficient of variation

**GI:** Green infrastructure

**GLUD:** Generalised land use database

**IMD:** Index of multiple deprivation

**LSOA:** Lower super output area

**NDVI:** Normalised difference vegetation index

**OSEI:** Organised social-ecological innovation

## **Glossary of terms**

### ***Adaptive:***

Within this thesis, *adaptive*, is used in the sense derived from the theory of complex adaptive systems (after Gundersson and Holling, 2002). Therefore, “adaptive” or “adaptation” in the context of OSEI is used generally with reference to the contribution of the latter to system resilience, as an adaptive response to environmental stressors, and specifically, with reference to the niche-driven occurrence of OSEI. The latter is presented in the thesis as a discussion of *types* of OSEI.

### ***Formal/informal/semi-formal green space management:***

Within the context of this thesis, *formal/informal/semi-formal* refer to green space management approaches. *Formal* in this sense denotes centralised, local authority-controlled management of urban ecosystems. Conversely, *informal*, describes a guerrilla approach to urban greening which occurs without the cooperation, or permission, of land owners or local authorities. Finally, *semi-formal* refers to innovative bottom-up initiatives of green space management but which, unlike a guerrilla approach, involve the cooperation of land-owners and local/environmental authorities.

### ***Governance:***

Where governance appears in this thesis it used in a general sense to refer to the collective management of urban green space within the defined study area. This definition includes the influence thereon of local authorities, organisations and individuals from both top-down and bottom-up directions and through formal and informal approaches to land-use. Where *adaptive governance* appears this refers specifically to an emphasis on building adaptive capacity as an approach to natural resource governance in social-ecological systems.

### ***Innovation/innovative:***

In the context of this thesis, the term innovation refers to novel interventions and participation from members of the community within the study area towards the targeted management of communal green space. Such intervention is deemed *innovative* from a natural resources management point of view in that it entails an increased and diverse stakeholder involvement in contrast to the widely established expert-led, centralised

approach to ecosystem management (Biggs et al., 2010). A fuller discussion of the meaning and implications involved in describing innovation is presented in Section 2.1.

***Landscape-scale:***

Within this thesis, where “landscape” or “landscape-scale” appears, it is used in reference to the particular context of this research and denotes the entirety of the study area comprising the adjoining districts of Manchester, Salford and Trafford. Where the term appears in the critical literature review, it is in reference to studies which focus on spatial patterns of multiple land-use or habitat types at city-wide or regional scales.

***Local-scale:***

The term “local-scale” is used herein to denote the physical extent of OSEIs and their immediate vicinity. Specifically with reference to the generation of ecosystem services, this refers to the receipt of those services at the neighbourhood-level.

***Micro-scale:***

This third scalar usage refers to the particulars of OSEI site design which contribute to, or reflect the production of, site-specific ecosystem service production.

***Multi-functional:***

With reference to urban green space, *multi-functional* describes the capacity of sites, by virtue of their design and management, to co-produce vital ecosystem services. In the context of this thesis, such multi-functionality refers to the ability of OSEIs to simultaneously produce desirable levels of the four key ecosystem services explored in the case study in Chapter 5 (see Section 5.1.5 for details and justification of selected services).

***Natural/naturalistic:***

Within the context of this thesis which takes the urban environment as its focus, the word natural refers to non-built elements in the landscape and, thereby, refers to all urban green space types occurring at all scales. The term naturalistic denotes, more specifically, green elements in otherwise highly built-up areas and to an approach to design and management of urban open spaces which seeks to emphasise such features.

***Planning/urban planning:***

Within this thesis the term *planning* is used in a general sense of making preparations towards future goals and/or devising novel ways to adapt to future circumstances. The term appears in this sense throughout the thesis as this form of thinking is closely tied to ideas of resilience and adaptive capacity which form a large part of the theoretical underpinning of this research. Where the term appears as *urban planning* this relates to the now multi-disciplinary profession involved in the architectural design and governance of towns and cities.

***Resilience:***

This research drew heavily on the theoretical model of resilience as a heuristic for understanding change in social-ecological systems (after Gunderson and Holling, 2002). Therefore, where the term appears herein it is used in this theoretical context as: “the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks” (Walker et al., 2004, p.2).

***Social-ecological memory:***

The accumulation and retention of knowledge and experience of ecosystem management which is held by communities and employed as a collective resource (see, for example, Barthel et al., 2010).

***Social-ecological system:***

An appreciation of the inherently linked systems formed by humans and the natural environment, to the extent that the two are seen as inseparable. The term was coined by Berkes and Folke (1998) to illustrate the equal importance of both aspects of the system.

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In memory of James Moran who would have grasped the complexity of things so much more clearly than I.

## Abstract

Urban areas are hubs of creativity and innovation providing fertile ground for novel responses to modern environmental challenges. One such response is the community-led management of urban green spaces as a form of organised social-ecological innovation (OSEI). Previous studies have attempted to conceptualise the ecological, social and political potential of such informal approaches to urban green space management. However, little work has been carried out into their efficacy in the landscape, either by describing the social-ecological conditions influencing their occurrence or by quantifying the actual benefits in terms of ecosystem service provision.

This research explores the emergence and impact of OSEI in a continuous urban landscape comprising the metropolitan areas of Manchester, Salford and Trafford (UK). The social-ecological context and content of OSEI were investigated using a cross-scale approach. At the landscape scale a snowball-sampling method mapped the occurrence of OSEIs using GIS and remote sensing technology. At the micro-scale, a case study quantified relative levels of provision across four key ecosystem services.

The analysis presented OSEI as an adaptive response to environmental stressors, clustered around “hubs” of social-ecological innovation in the urban landscape. The distribution of OSEIs was influenced by historical context, degree of urbanisation and dependent on levels of, and dynamics between, social and ecological deprivation. Urban agriculture was instrumental as a catalyst for the emergence of OSEI and the associated production of a range of ecosystem services. Site productivity was also influenced by spatial and design considerations.

This thesis has detailed the character of OSEI as a coherent phenomenon in the urban landscape which exhibits valuable response diversity according to social-ecological conditions. This, together with an evaluation of factors influencing ecosystem service provision at the local scale, has informed the validity of OSEI as an element of adaptive capacity which contributes to resilience in urban social-ecological systems.



*No guru, no method, no teacher*

*Just you and I, and Nature ...*

*In the garden, wet with rain.*

- George Ivan Morrison.

## Chapter One: Introduction

Since the end of the Pleistocene and the beginning of the Holocene period around 12,000 years ago, the presence of human beings on this planet has become increasingly conspicuous as mankind continually makes technological leaps in agriculture, animal husbandry, tool-making and harnessing of combustion, through to the more recent industrial, nuclear, information and digital revolutions. So much have humans made their mark on the planet (or on the surface at least) that many scientists have heralded the modern industrial era (since the 1800s) as the Anthropocene (e.g., Crutzen, 2002; De Vries and Goudsblom, 2002; Syvitski et al., 2005; Ruddiman, 2005; Steffen et al., 2007), pointing to the activities of people as the defining environmental, if not geological, characteristic. Many look to the rise of industrialisation as being synonymous with the coming of the Anthropocene in that it marked the beginning of perhaps the greatest driver of environmental change associated with humans – that of the release of anthropogenic carbon dioxide into the atmosphere, now considered the main cause of climate change (see, for example, IPCC, 2007 or Solomon et al., 2009).

The Anthropocene has been characterised primarily by urbanisation, in so much as the city has been the source of innovation in terms of technology and learning as well as the site and/or the recipient of much of the industrial activity of the past two centuries. This in turn has fuelled the rise and expansion of urban areas into the modern megacities which home a significant and growing proportion of the global population today and some are now using the term Urban Anthropocene to reflect this phenomenon (e.g. Ljungkvist et al., 2010).

This global trend towards urban migration is such that the population scales have recently tipped. For the first time, over half of people worldwide now live in urban areas (United Nations, 2007). This development has far-reaching, often harmful consequences for human well-being, biodiversity, sustainability and the future of human-nature interactions (McKinney, 2002). There have been creative responses across a variety of academic disciplines to this development which, if nothing else, have succeeded in broadening the frame of reference which can and ought to be applied to a thorough appreciation of the social and ecological implications of urban growth. Such an appreciation includes progressive disciplines such as social ecology, political ecology, ecological economics, climatology, and

sustainability. The social aspects of ecological and environmental science have been recognised as indispensable and, indeed, undeniable (Bradshaw and Bekoff, 2001). This recognition however, is somewhat overdue on the part of physical scientists and has been implied for some time in the work of sociologists such as Norbert Elias (Loyal and Quilley, 2004) who first proclaimed that civilisation had advanced to such a degree that the relationship between humans and nature had flipped. As such, the “biosphere” could now reasonably be said to be contained within the “anthroposphere” (whereas previously the reverse was true), such is the extent of man’s influence on global environmental conditions. To some degree then the horse has already fled the stable and only now are environmental scientists and ecologists attempting to describe the processes at work in this vast social-ecological paradigm which has led to the current global social-ecological conditions.

Thus, it has been acknowledged that, especially in this modern age, the social and ecological realms are rarely, if ever, separable and in order to appreciate the simultaneity and complexity of human-nature processes, the concept of the social-ecological system (SES) has proved apt and beneficial for investigating and developing management strategies for systems where the interaction between the social and natural worlds is particularly amplified and/or complex (Berkes et al., 2003, Walker et al., 2006). This new appreciation of the complexity of social and ecological relationships has, for the most part, put asunder the idea that social, economic and ecological attributes of a system can be effectively analysed as discrete phenomena. This comes with the recognition that we are only just beginning to understand the extent of the simultaneous, multi-scale interrelationships and feedback mechanisms which are to be found throughout social-ecological landscapes (Alberti, 2005). Such complex adaptive systems appearing in their most extreme form as modern towns and cities, require adaptive, innovative governance in order to intelligently navigate the array of internal and external fluctuations which distinguish them (Biggs et al., 2010). It has been recommended that adaptive, polycentric governance in social-ecological systems may be enhanced by collaborative approaches to natural resource management (Ernstson et al., 2010) which promote stakeholder engagement, social-ecological learning and local stewardship of ecosystem services (Biggs et al., 2012). A recent surge of public environmental awareness and concerns over food poverty has led to an increase in the prevalence of civic ecological activities centred around, for example, nature conservation

and informal agriculture (UK NEA 2011). However, it has also been highlighted by the same research (UK NEA, 2011) that the processes through which people come to social-ecological activities and educational opportunities are little understood.

The research reported in this thesis explores the current state of the social-ecological landscape in those areas where the human and natural aspects of our world are, fortunately or unfortunately, most turbulently conjoined: namely, our towns and cities. The urban environment is unique in that it is, oxymoronically, the appearance and growth of our towns and cities that have reflected and fuelled mass industrialisation whilst at the same time it is the very environment from which social and scientific innovation, key to solving the problems brought about by such industry and commercialism, is most likely to emerge. Moreover, urban areas exhibit high levels of environmental inequality in terms of green space provision and, therefore, natural resources take on disproportionate cultural significance (UK NEA, 2011). Such a situation further heightens those social-ecological tensions which may provide a rich context for examples of environmental activism (Cattell 2001). However, sufficient evidence for the translation of such increased awareness and environmental participation into adaptive capacity in urban social-ecological systems is, as yet, lacking. In order for stakeholder participation and local stewardship of urban green space to be viable contributors to system resilience, they must demonstrate adaptive and diverse responses to internal and external social-ecological pressures as well as effective maintenance of vital ecosystem services. The aim of this thesis is to detail and evaluate this contribution.

## **1.1 The conurbation of Greater Manchester as a modern social-ecological system**

The geographical context of this work was the conurbation of Greater Manchester, UK. As a modern post-industrial centre, Greater Manchester enjoys and suffers many of the features of a densely populated, burgeoning urban area. The natural, industrial and cultural heritage of this city forms a rich tapestry and as such is a keen example of the complexity of a modern-day social-ecological system with all its challenging finery.

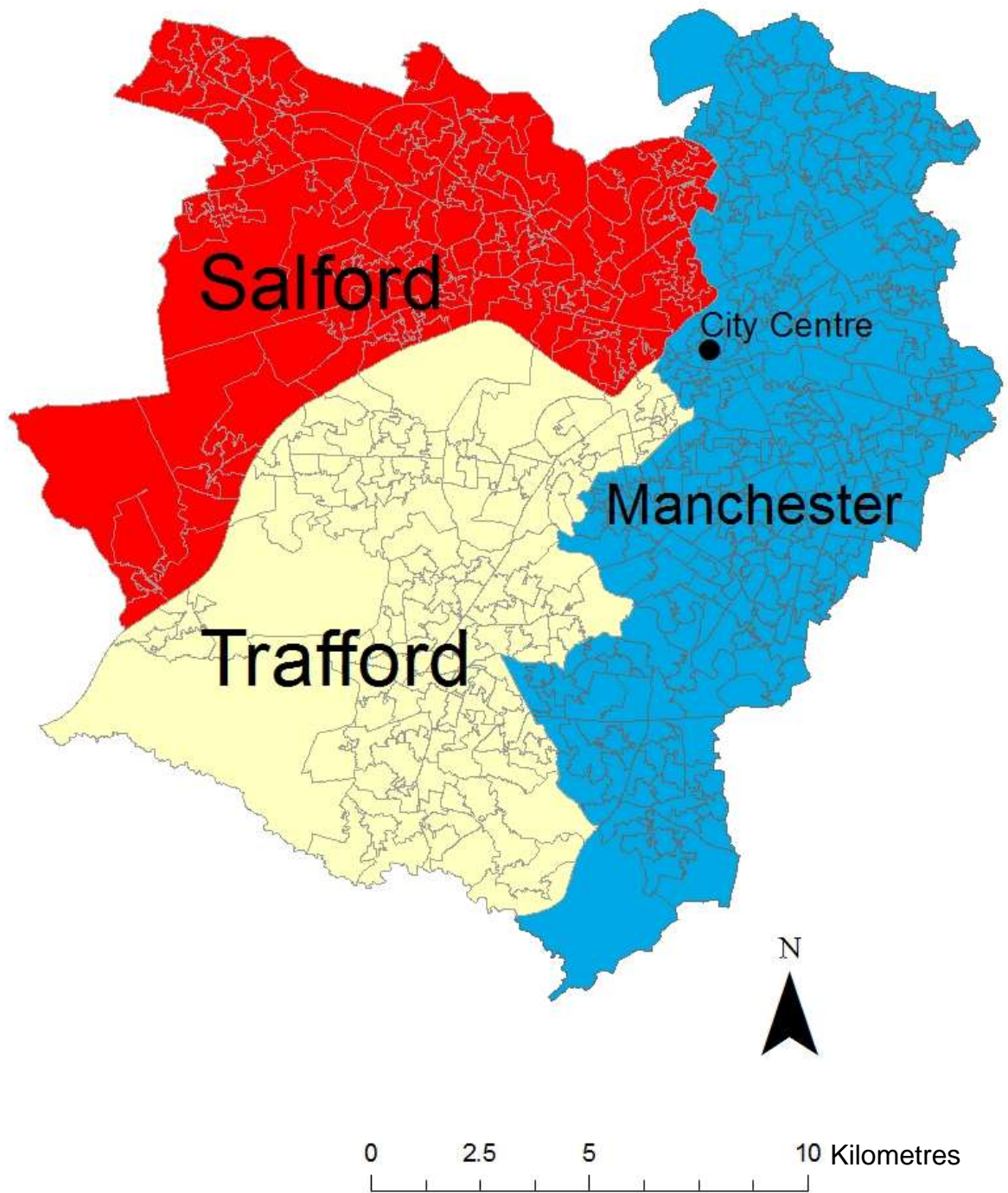
The population of Greater Manchester recently reached 2,682,528 according to the 2011 census and the conurbation covers a total of 127,603 hectares (ONS, 2011). The area

comprises the metropolitan boroughs of Trafford, Wigan, Bury, Oldham, Rochdale, Stockport, Bolton and Tameside and the cities of Manchester and Salford. The Greater Manchester Built-Up Area as defined by the Office for National Statistics is the second most populous conurbation in the UK outside of London (ONS, 2013).

Historically, Greater Manchester has been largely known for its prominent role in the context of the industrial revolution both domestically and internationally. It was the heart of world cotton trade and considered by many to be the world's first industrial city (Kidd, 2006). It has since undergone continuous redevelopment as a centre of chemical and electrical engineering and, more recently, commerce and finance. Despite the dramatic effects on the landscape that go with industrial development and continuously increasing infrastructure, the Greater Manchester area retains a significant area of quality natural spaces and contains twenty-one Sites of Special Scientific Interest. Post-industrial landscapes across the region, in their disuse, have been colonised by wildlife and in turn become Sites of Biological Importance such as in the case of the Wigan Flashes: large bodies of water created in the wake of coal-mining industry which form current-day nature reserves. The Manchester Mosses comprise some of the last remaining peat bogs in the North West and are designated as a Special Area of Conservation (SAC) under the EU Habitats Directive. The urban area contains over 60 Local Nature Reserves (GMEU, 2010). An appreciation and support for the unlikely array of important post-industrial habitats is not an entirely new phenomenon and Greater Manchester has a history of committed environmental action that parallels its fierce modernisation by industry.

Greater Manchester's importance at the launch of the industrial revolution placed it in the uncomfortable position of having to find ways of coming to terms with the consequences of such rapid social and environmental change. For this reason there is a strong record of environmentalism in the culture and history of Greater Manchester and its environs. From the 17th Century "Diggers" movement inspired by Wigan-born Gerald Winstanley (the name Diggers was given to the group as a result of their attempts to farm common land) and the Rochdale Pioneers whose activities lead to the beginnings of the modern cooperative movement in 1844 (Walton, 1997), to the protests over the industrial annexing of Thirlmere in the Lake District in the 1880s (Ritvo, 2010) the roots of environmental activism run deep and long into the past. This research took Manchester, Salford and Trafford as its

geographical extent which, due to the unique administrative boundaries, can be said to form a coherent inner-city zone with continuous surrounding suburban areas (Manchester City Council 2012). As such these three areas form, collectively, the most densely populated part of the conurbation and provide the most suitable environment for the interests of this research into the social-ecological landscape of our towns and cities. The study area with administrative boundaries is presented in Figure 1.1.

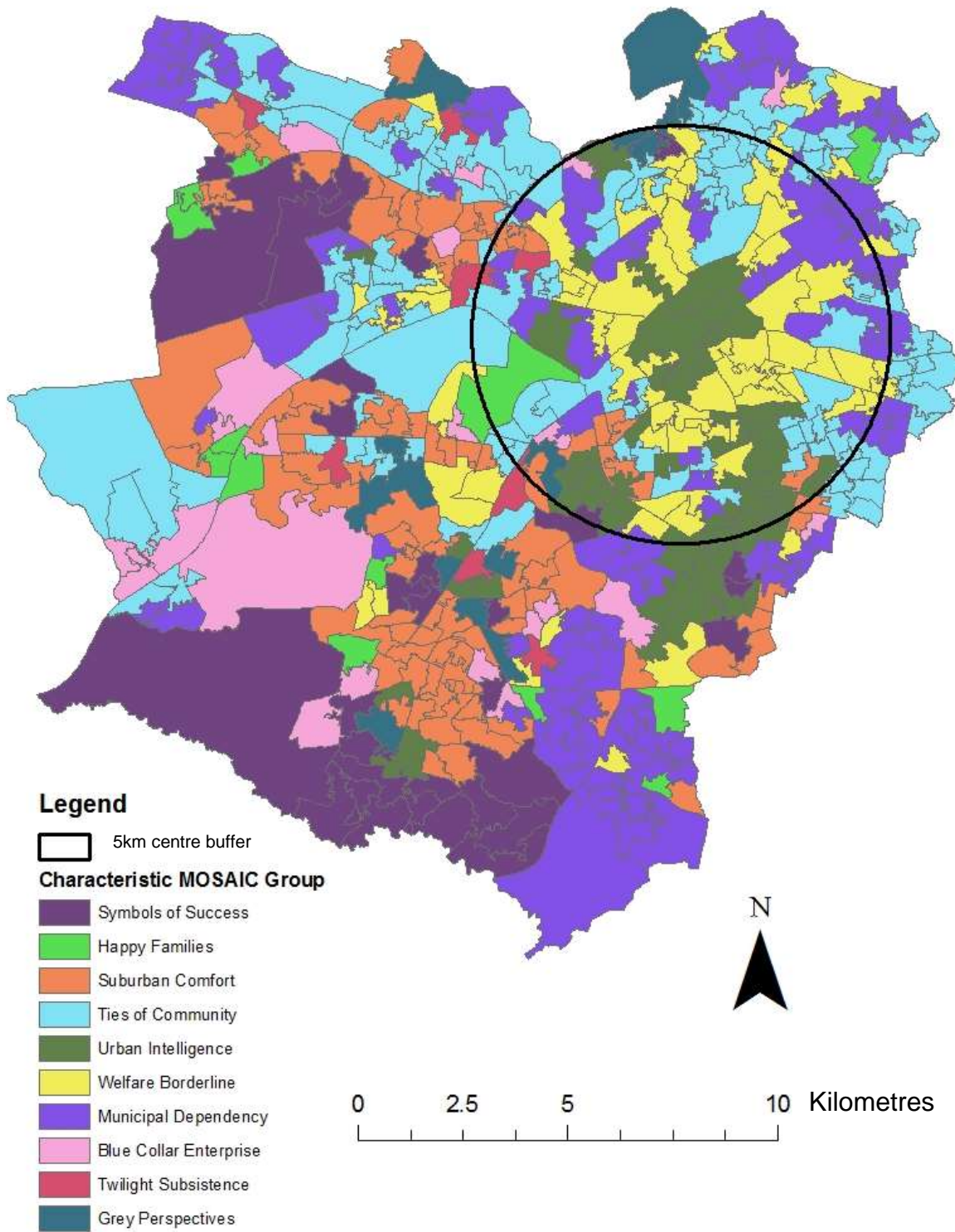


**Figure 1.1** Study area with administrative boundaries (lower super output areas) and Manchester city centre (ONS, 2011).

The individual populations of Manchester, Salford and Trafford were, at the time of writing, 503,127; 233,933 and 226,578 respectively, totalling just fewer than one million residents with a population density of 30.2 persons per hectare for the combined area (ONS, 2011). This compares to figures of 21 persons per hectare for Greater Manchester and the national average of 2.6 persons per hectare for the UK. The city of Manchester itself has one of the highest population densities in the UK outside of London with 43.5 residents for each hectare (ONS, 2011). This places Manchester at the extreme edge, in UK terms, of the complexity and severity of anthropocentric landscape change that can be observed in 21st century urban settlements and as such provides a salient illustration of human-environmental interactions. Such interaction takes place across several scales of influence and authority from both top-down government led development as well as from “bottom-up” initiatives and community-led services which have received increasing onus and scrutiny in light of the decentralising of public services as promoted through UK government policy (Cabinet Office, 2013). As will be seen, this re-working of community services and responsibility will provide a sharp context for the focus of this research.

The socio-economic commonalities of the study area are well described by an analysis of neighbourhood characteristics based on Experian MOSAIC data. Figure 1.2 presents the most highly represented MOSAIC group for census classification areas (lower super output areas) in the study area with a five kilometre proximity buffer circling the city centre and inner-city region.





**Figure 1.2 Study area most representative MOSAIC group by LSOA (ONS, 2001).**

Figure 1.2 demonstrates that neighbourhoods in the inner-city area highlighted, which surrounds the central business district and intersects with large areas of all three administrative areas, share many of the same socio-economic characteristics. The majority of neighbourhoods in these areas fall into, of the eleven designated MOSAIC categories, the four groups: “Ties of Community”, “Urban Intelligence”, “Welfare Borderline” and “Municipal Dependency”, with comparable group membership throughout the three districts, highlighting the demographic homogeneity of this central urban area as a whole.

## **1.2 The modern social-ecological Landscape**

The environmentalist impulse has continued into the present and recent public concern over climate change and a need to embrace sustainable alternatives to the historical, linear approaches to environmental resilience have bred a new generation of social-ecological actors in the Manchester urban landscape. The “Diggers” movement has been continued in the form of community action and guerrilla gardening groups such as the “squatted” Leaf Street Community Garden in Hulme where residents exercised community ownership of communal green space, and the more recent Urban Gardening Project in Moss Side – both movements occurring in areas characterised by high levels of multiple deprivation and limited access to green space (see Section 4.2 for analysis). In the 1990s a group of four environmental activists came together to create Manchester’s first environmental resource centre at Bridge 5 Mill, just north of the city centre, raising over three million pounds in the process. This paved the way for a creative and extensive network of social-ecological innovation within the modern urban tapestry. The Manchester Environmental Resource Centre Initiative (MERCi) became host to many local community-engendered environmental initiatives, such as The Environment Network for Manchester (EN4M); Herbie, a mobile grocery service set up to provide affordable, fresh fruit and vegetables to residents living in areas of East Manchester with poor access to fresh food; Sow Sew, a project which uses “meanwhile” sites to grow sustainable fabric crops, and a specialist environmental consulting service, “Sustaining Change”. The building has also hosted environmental partners such as the Federation of City Farms and Community Gardens, the Black Environmental Network and the Manchester Environmental Education Network (MERCi, 2015). Sister initiatives have sprung up around the city since the inception of Bridge 5 Mill sharing its collective ethos of sustainability, action on climate change and community capital.

Organisations such as Hulme Community Garden Centre, The Kindling Trust and Action for Sustainable Living have secured significant amounts of funding and delivered environmental and educational projects across the city (Lockwood, 2008; KindlingTrust, 2015; Action for Sustainable Living, [no date]).

Through first-hand observation it was postulated that such organisations might constitute hubs of social-ecological activity. A network of community groups, resource centres, gardens and allotments has emerged over recent years, which, for the purposes of this research thesis, will be referred to as instances of Organised Social-Ecological Innovation (OSEIs). The definition and theoretical underpinning of the concept of social-ecological innovation is provided in Section 2.1 of this thesis. Specifically within the context of this thesis the term applies to instances of the bottom-up, community-led management of urban green space which stands in contrast to the largely centralised, expert-led forms of natural resource governance (Biggs et al., 2010).

Within the remainder of this thesis the term *organised* social-ecological innovation (OSEI) will be used to differentiate the subject of this research from other highly informal or illegal forms of social-ecological activity such as seen in examples of guerrilla gardening (see Hardman, 2014). Contrary to such practices, OSEI can be seen as an approach which seeks proper establishment and self-continuation through collaboration with land owners, local authorities, charities and other stakeholders. In this respect OSEI differs from a guerrilla approach as it generally aims at legitimacy by integrating itself into local green space management through the cooperation of land owners and community members.

Furthermore, the term *organised* denotes a certain level of group organisation and the provision of on-going activities and resources to service users, as opposed to purely physical non-interactive forms of urban ecological innovation such as green roofs or rain gardens.

In order to fully understand both the social and ecological context, the history as well as the scientific research informing understanding of such innovation, a review of the scientific literature to date was carried out. This covered all aspects of social-ecological systems, urban ecology, ecosystem services, civic ecology and related topics such as resilience theory, sustainable development, complexity, systems theory and public health in order to appraise the current understanding in this area of research and to identify any apparent gaps in knowledge. This is presented in Chapter 2 of this thesis. Following this critical literature

review it had been noted that among the current body of research on the subject there was little close examination of the nature and extent of social-ecological innovation, much less of such innovation in an urban setting and virtually none of the links between such innovation and the provision or protection of vital ecosystem services. Accordingly, a set of aims and objectives were established that served to address this shortcoming in mapping and evaluating this characteristic of the social-ecological urban landscape.

Chapter 4 in this thesis includes the results of a mapping exercise which evaluates the extent of instances of social-ecological innovation and explores the notion of social-ecological “hubs” in the landscape. The results of this mapping exercise will also shed light on the geographical and socio-economic context of instances of OSEI across Manchester, Salford, and Trafford using Office for National Statistics (Index of Multiple Deprivation and Generalised Land Use Databases), UK census, Landsat data, and Experian MOSAIC data to identify social-ecological trends in the distribution of OSEIs and possible environmental and cultural correlations.

Chapter 5 presents the details of a case study of twelve sites of organised social-ecological innovation (OSEIs) covering discrete *types* of OSEI (identified through the mapping exercise in Chapter 4). A justification is provided of site selection and the specific ecosystem services to be investigated in order to evaluate the impact of such innovation. The subsequent sections in Chapter 5 present the methods chosen for data collection in the case study and the results of the site evaluations and ecosystem services assessments, with preliminary discussion.

Chapter 6 presents a projected monetary valuation of OSEI in the study area landscape and an analysis of trade-offs and synergies present in OSEI productivity in terms of ecosystem services. Exploration of productivity and variance in service provision by sites is enabled by the standardising of service production by site size and as a percentage of the overall product for the case study. Elements of site design and management which contribute to ecosystem services are also explored in terms of synergistic relationships with overall productivity.

Key findings are summarised in Chapter 7 along with recommendations for future research. Planning considerations are outlined based on an appreciation of the unique attributes of OSEI at both the landscape scale and the micro-scale as detailed in the preceding chapters 4 to 6.

## Chapter Two: Literature Review

### 2.1 Social-ecological memory, learning and innovation: teaching a new dog old tricks?

The role of innovation is acknowledged as key for the success of the natural resource management goals (Rennings, 2000, Lebel et al., 2006). With cities historically being the centre of human innovation and creativity (Dvir and Pasher, 2004) this places cities in the curious position of both perpetrator (of land use change) and protector (through innovation) simultaneously. As such, urbanisation has been presented as an environmental process which offers some of the greatest challenges but, also, some of the greatest opportunities for resilient ecosystem services management, through innovative and adaptive resource management and governance tools (CBD, 2012). However, notwithstanding the importance of the role of innovation, little research has been done into the landscape-scale distribution of innovations of a social-ecological nature within the urban environment (Janssen et al., 2006), nor into the productivity and impact of such innovation at the local neighbourhood scale. It is important to bridge this gap in knowledge as, following the conclusions of resilience theory (Anderies et al., 2004), diverse social-ecological networks may hold some of the keys to adaptive urban management into the future.

Further research into the dynamics of cross-scale, flexible governance may also shed light on the desirability (intentional or otherwise) of policies which promote the devolution of public services (including green space management) for urban resilience (Biggs et al., 2012) and the successful provision of ecosystem services (CBD, 2001). The social-ecological capital embodied in the presence of such networks, if recognised and integrated into current urban green space management, could serve to decentralise and diversify environmental resource governance models, thereby improving their resilience (Armitage, 2005; Bodin et al., 2006). Specifically, an understanding of the extent and impact of local social-ecological actor groups, which potentially facilitate and mediate the productivity of urban green space in terms of ecosystem services, would inform an appraisal of the contribution of such innovation towards adaptive capacity and response diversity to social-ecological stresses.

Some studies have already shown that environmental education and ecology-based learning are central to transforming behaviours and comprise one way of diffusing innovative ecological ideas and activities (Alaimo et al., 2008; Larsen et al., 2010). Innovative resident-led gardening and nature-based community groups, a social-ecological system, draw on social-ecological memory and concepts of food heritage and sustainability. Such community-led initiatives attempt to alleviate the social-environmental stresses of urban living through constructive and innovative uses of green commons. It has been suggested that such practices help participants in terms of improved diet (Alaimo et al., 2008; Kazmierczak et.al, 2013), access to food (Metcalf and Widener, 2011), personal well-being (Pudup, 2008) and better quality of life factors such as reduced crime (Kuo et al.,1998; 2001). They have also been championed as methods of “cultivating” citizenship (Pudup, 2008), adding to and preserving local social-ecological memory (Barthel et al., 2010) as well as contributing to green infrastructure in the urban landscape in line with the UK government’s insistence on the importance of green infrastructure in urban landscapes as outlined in the 2011 Environment White Paper (Defra, 2011). Community-led ecological initiatives aimed at environmental education and stewardship can go some way to bridging the disconnect that exists between humans and the environment. This disconnect results largely from the increasing trend, since the industrial revolution, of the withdrawal of people from rural areas into urban ones and accompanies an indifference towards the natural world which has detrimental consequences for the environmental conservation agenda (Miller, 2005). The promotion of environmental awareness and opportunities for positive human-nature interactions may help to reverse this trend and create more environmentally conscious communities and cities.

## **2.2 Defining social-ecological innovation**

Social-ecological innovation may appear in a variety of forms and contexts. Informal management of communal green spaces by urban residents has been posited as one social-ecological measure that may be key in the building of more resilient cities in light of the major challenges they face (Ernstson et al., 2008; Colding and Barthel, 2013). There have been assertions in the scientific literature that the devolution of highly centralised

approaches to natural resource management, focussing on collaborative networks and decentralisation of governance, ought to be beneficial from a resilience theory perspective (e.g. Andersson et al., 2007; Biggs et al., 2010).

In an attempt to create a working definition of the concept of social-ecological innovation Olsson and Galaz (2012) provided a set of criteria by which interventions can be said to be innovative solutions to social-ecological challenges.

They define social-ecological innovations as those which:

- i) Address the social, ecological and economic aspects of the situation.
- ii) Enhance quality of life for humans without causing degradation of the environment.
- iii) Address multiple social-ecological challenges simultaneously and adaptively.
- iv) Work towards common social-ecological goals rather than profits for individuals.
- v) Create social-ecological feedbacks which allow for working and remaining within planetary thresholds as vital for the safety of humanity.
- vi) Involve the creativity of users, citizens, consumers, activists and workers.
- vii) Utilise social-networks to create change across scales.

In order to fully understand and evaluate the emergence, dynamics and impact of such innovation, it is necessary to understand the context in which social-ecological innovation occurs. The criteria above are underpinned by resilience thinking (Olsson and Galaz, 2012), an approach which has increasingly become concerned with the management of ecosystem services (Biggs et al., 2012). Both resilience theory and the ecosystem services framework have emerged from the broader body of research into social-ecological systems. An appreciation of the latter is crucial in identifying and evaluating innovation of a social-ecological nature.

### **2.3 Understanding and management in social-ecological systems**

Glaser et al. (2008) p.8, define a social-ecological system as “a bio-geo-physical unit and its associated social actors and institutions”. While this definition seems to paint a picture of a modern industrialised scenario, social-ecological systems come in many unique varieties and much of the early research which has been typically carried out into such systems has focussed on rather simplistic interactions between humans and nature, emphasising

management in the face of uncertainty (Berkes et al., 2003). Case studies have often focussed on the characteristics of the natural component of the system and the ways in which the integrity of the ecological processes can be managed in the face of human exploitation. In this vein, research has typically looked at discrete, easily observable natural systems such as riparian and coastal communities, and fishing activities (Walters, 1997; Gunderson and Holling, 2002).

Such case studies have offered clear-cut examples to explore the exploitation of natural resources (e.g. fish) by humans in a close-knit system and have been forerunners of research carried out into the resilience of these systems. Likewise, much of the work undertaken into social-ecological systems has issued from a management perspective and out of a concern over the ability of ecosystems to maintain their functions (Walters and Holling 1990; Kremen 2005, de Groot et al., 2010). It is not surprising, therefore, that the exploration of social-ecological systems has been married to the development of resilience theory over the past few decades.

Resilience as a broad concept has for a long time accompanied the management of the natural environment by humans with varying success (Holling, 1973). It is not a polished concept by any means and beyond certain initial premises, it is subject to a host of unpredictable variables presented by highly stochastic human-nature scenarios (Folke 2002). In fact, it is often the case that only after the resilience of a system has been tested by a disturbing event and a subsequent reconfiguration of “stable” states within that system has been observed that anything certain can be said about its resilience (Gunderson, 2000).

For this reason, a re-appreciation of the value of human-ecological memory is being seen amongst ecologists as well as sociologists and planners in general (Gunderson and Holling, 2002; Young, 2009; Defra, 2010a). Subsequently, the extent that research into management practices as can be observed in indigenous cultures around the world are being studied as possible historical examples of how to manage social-ecological relationships towards future resilience (Berkes, 2008; Barthel, 2011). This attitude not only highlights the importance of adaptability and social-ecological memory but also infers a need to assess what we judge to be indigenous. In the industrialised world this idea seems to be an anthropological relic not relating to modern urban citizens but even cities are landscapes with social-ecological memory and the vessels of such knowledge are the individuals and institutions “indigenous”



to a given area (Barthel et al., 2010). This new appreciation of ecological resilience constitutes a re-analysis of the older ecological idea of “engineered resilience” which typically involved a maximum yield approach to the resilience of human-exploited ecosystems (Holling, 1996). In other words, the ability of a system to recover from such modification by humans (its resilience) was simply seen as the amount of time taken to return to its original, stable condition after a disturbing event. The linearity of this model betrayed a lack of understanding of the multi-scale, multi-state characteristics of ecosystems. This was exposed by Holling in his seminal paper on the non-linear definition of system resilience in 1973. In this paper he proposes that resilience was a dynamic process whereby ecosystems shifted between basins of attraction depending on the range of their biological parameters, i.e. that they can “flip” between stable states as a result of high levels of disturbance.

This dynamic has great implications for ecosystem management and as such has closely accompanied the development of our appreciation of social-ecological systems. Although there is some confusion in the literature of a working hypothesis of this “new” resilience (Walker et al., 2004), in the case of social-ecological systems, Walker et al. (2004) have suggested that the future projections of such systems are subject to three determining factors: resilience, adaptability and transformability. They describe resilience here as the ability of a system to undergo disturbance whilst maintaining its essential functions; adaptability as the ability of core actors within the system to influence resilience; and transformability as the capacity to assemble an essentially new system when the current one becomes untenable. What is perhaps more pertinent here is that these determining factors can be applied to a host of “systems” - social, ecological, institutional, organismal, political, or economic, for example. In the case of the social-ecological system it is interesting to note that humans are the core drivers or “actors” of change and as such are in the precarious situation of being elements of the system which they simultaneously must endeavour to manage. That is to say, humans necessarily influence the resilience of the system and to a large extent it is a question of managing ourselves through our own capacity for (social-ecological) memory, learning and planning. This dynamic is particularly salient in the case of the urban social-ecological system which provides the physical and theoretical context of this research. Accordingly the use of the term *resilience* within this thesis refers to the capacity of social and ecological elements with an urban social-ecological system to navigate

perturbations by adapting to circumstances or by forming new functional assemblages following a collapse in the system regime, or parts thereof.

The dynamics of social-ecological system processes occur at various scales and are subject to cross-scale non-linear interactions (Gunderson, 2001). The cycles of transformation and adaptation which underpin such close-knit social-ecological systems are described by the related concept of the adaptive cycle (Gunderson and Holling, 2002). In this framework, ecological and social systems alike are subject to a four-phase cycle of transformation as follows: 1) exploitation ( $r$  phase); 2) conservation ( $K$  phase), 3) release ( $\Omega$  phase) and 4) reorganisation ( $\alpha$  phase). The cycle is most clearly exemplified through ecological analogy whereby the  $r$  phase is characterised by the colonisation by species tolerant of recent local environmental changes, the following  $K$  phase comes to be dominated by more adaptive species, the  $\Omega$  phase is typified by some form of environmental collapse or shift such as a forest fire while the final  $\alpha$  phase describes the reorganisation of the system providing new social or ecological configuration for exploitation. The four stages of the adaptive cycle are equally applicable to social systems and to coupled social-ecological systems. Figure 2.1 illustrates this process.

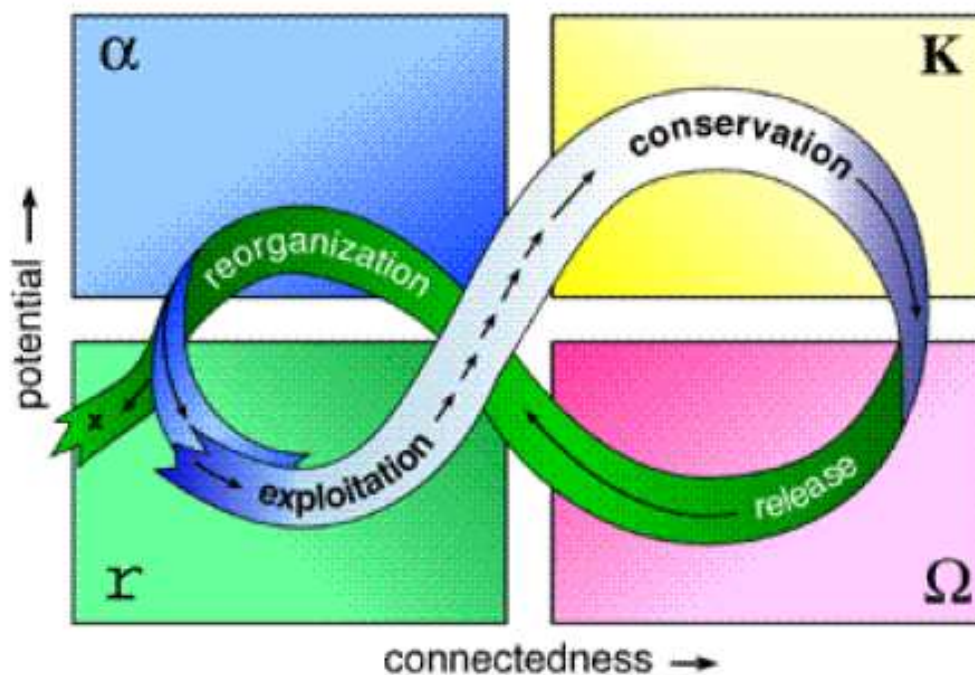
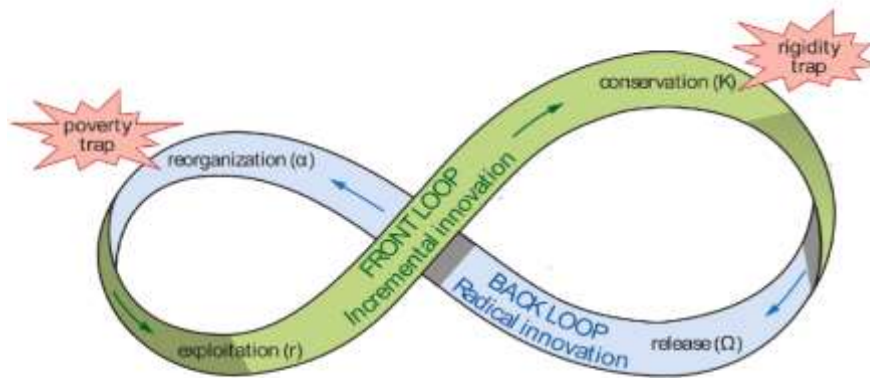


Figure 2.1 The four phases of the adaptive cycle in social-ecological systems (Gunderson and Holling, 2002).

The main variables which drive the movement of a system through the various stages of the adaptive cycle are potential and connectedness. Potential is at its highest during times of re-organisation following the release/destruction stage. Connectedness within a given regime is one of the main casualties of system collapse but the breakdown of rigid connections directly allow the re-emergence of new creative organising relationships within the social or ecological landscape (Folke, 2006). With the gradual establishment of new innovations and thresholds in an alternative system configuration following the *r* phase, connectedness grows as new social and ecological networks become increasingly consolidated. This has the overall effect of saturating the network with a rigid array of coupled connections – increasing dependency on particular relationships and configurations thereby decreasing the flexibility and resilience of the system priming it for eventual collapse and entry into the release phase (Gunderson and Holling 2002). Very high levels of connectedness and dependency on particular social-ecological structures can result in “rigidity traps” whereby systemic controls prevent the necessary degree of flexibility for effective adaptation to outside environmental change (Carpenter and Brock, 2008). Rigidity traps have a salient bearing on urban social-ecological systems whereby highly centralised approaches to ecosystem management can lead to the over-standardisation of green space design and management (Alberti and Marzluff, 2004). Likewise, poor connectivity and lack of self-organisation within the social-ecological system, or parts thereof, are prone to creation of “poverty traps” (Allison and Hobbs, 2004). This results in the inability for new ideas, resources and adaptive responses to spread throughout the system in response to outside stresses and internal fluctuations. Again, in urban social-ecological systems, where the social and natural environment is intensively managed by people, the existence of potential poverty traps can be particularly deleterious to the ability of the system to cope with stress and transformation. Such traps and their position in the adaptive cycle are visualised in Figure 2.2.

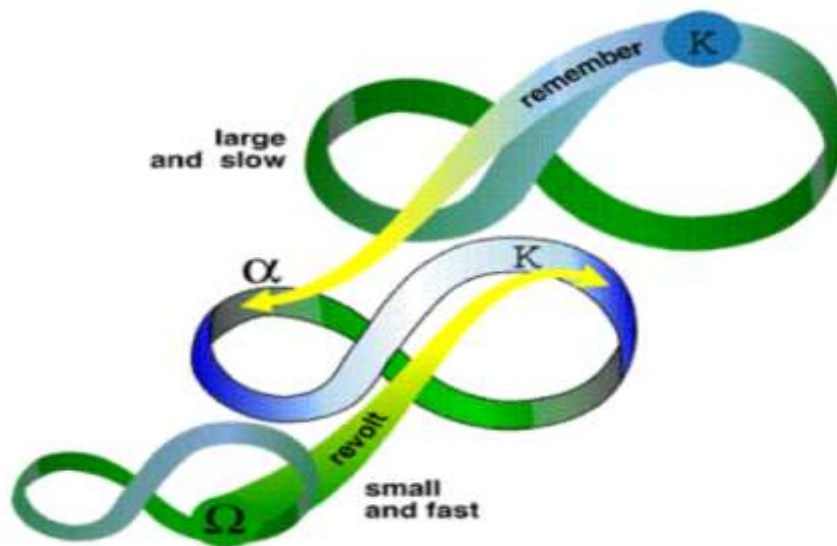


**Figure 2.2 Adaptive cycle and associated "traps" (adapted from Biggs et al., 2010).**

The adaptive cycle itself is, in terms of growth, destruction and regeneration, characterised by periods of incremental growth and innovation whereby existing steady states after a period of exploitation are increasingly consolidated and conserved as the capacity for management and organisation become more efficient. This period is described by the “front loop” in the adaptive cycle visualisation. Conversely, the “back loop”, following a period of system collapse and regime change, is characterised by more radical innovation and re-organisation whereby new system thresholds and rules are re-created and eventually established (*r* phase). The inventiveness and ingenuity which often accompany the “back-loop” stages in the adaptive cycle offer good examples of how nested cycles, operating at smaller scales can create cross-scale effects as successful innovations are widely adopted such as the global influence of the rise of agricultural practices and the modern ubiquity of the internet (Biggs et al., 2010). Innovation is of vital importance to system resilience through the emergence of adaptive responses to changing social-ecological conditions (Olsson et al., 2006). The ability to adapt accordingly is one measure by which elements within a system, such as social-ecological actors in urban areas, may be assessed as contributing positively to overall system resilience.

The application of such models of systems transformation to real-life examples, however accurate, does not acknowledge the cross-scale complexity of actual social-ecological systems. In order to address and include such complexity in their model Gunderson and Holling (2002), in their promotion of the concept of cross-scale panarchical cycles, describe

complex system processes as a collection of nested adaptive cycles embedded in an overarching system “panarchy”. This non-linear, cross-scale approach to systems analysis describes complex nested adaptive cycles which co-influence the transition from one adaptive phase to the next. Often in this framework, smaller cycles subject to faster rates of change are embedded in larger cycles which provide a background system operating of larger physical and temporal scales (Gunderson and Holling, 2002). As a rule, adaptive cycle stages of a given nested system are conditioned by trends in the background system. For example, local regeneration and exploitation (*r* phase) of a forest ecosystem after regime change resulting from extensive fire damage is, to a large degree, conditioned by slow variables such as the previous build-up of soil nutrient levels and seed bank governed by the overall soil ecological processes of the wider system. This kind of cross-scale interaction (from larger, “slower” cycles to smaller “faster” ones) is referred to as a “remember” intervention. Interactions of this nature also occur in the opposite direction (from smaller to larger cycles) usually as the result of a catastrophic event leading to entry into the  $\Omega$  phase, the effects of which can cascade up and trigger parallel cycle transformations at higher levels in the system panarchy. Such events are termed “revolt” interactions (Holling et al., 2002). As such, co-occurring adaptive processes come to bear influence across physical and temporal scales. Nowhere is this phenomenon more acutely relevant than in the case of urban social-ecological systems. The theoretical tools of adaptive cycles and associated notions such as adaptive capacity and response diversity, and an emphasis on social-ecological feedbacks, have proven useful in understanding and conceptualising complex adaptive systems, such as those found in urban areas (Ernstson et al., 2010; Ahern, 2011). Such cross-scale effects are visualised by connected, multiple adaptive cycles as in Figure 2.3.



**Figure 2.3 Social-ecological systems panarchy (Gunderson and Holling, 2002).**

However acceptable the determining factors outlined by Gunderson and Holling (2002), they still do not escape the problem of multiple interpretation of ideas such as resilience, adaptability, and transformability not to mention a whole host of related terms such as “precariousness”, “resistance”, “robustness”, “vulnerability”, and “risk” (see, for example, Millennium Ecosystem Assessment, 2003 or Gallopin, 2006). Furthermore, few empirically based studies have been conducted to verify quantitatively the assumptions made around adaptive cycles in complex systems. That said, as a theoretical tool, the adaptive cycle framework, and associated concepts such as rigidity and poverty traps, response diversity and redundancy, offers an effective model through which to assess and manage the capacity of social-ecological systems in the face of uncertainty and change. The theory, would, however receive greater validation through the carrying out of research which provides demonstrable, quantitative examples of ecosystems management performance described through its tenets. Later research within this thesis provides such an example (summarised in Section 7.5).

All such concerns have emerged from the greater back-drop of the movement towards global sustainability which has become the paragon of the environmental movement since its inception at the Earth Summit in 1987. Its tenets of sustainable development, sustainable consumption, ecological citizenship as well as associated models and policies such as the ecological footprint and Local Agenda 21 (WCED, 1987), represent the emergence of another scientific vernacular concerning environmental stability. The concept of sustainability is

bound up in various attempts to ensure the preservation of opportunity and welfare for future generations. Of these, the two somewhat opposing notions of *weak* and *strong* sustainability have arisen. The former posits the substitution of human forms of capital, often derived from gains achieved by industrialisation such as energy or intensive agriculture, for natural forms (Cabeza Gutés, 1996). In contrast, *strong* sustainability places greater emphasis on the need to conserve ecosystem functions from which, ultimately, both forms of human and natural capital arise (Ayres et al., 2001). In this sense, the latter shares some theoretical foundation with resilience thinking in that it acknowledges the need to work within ecosystem thresholds in order to avoid possibly undesirable systems transformations. Likewise, strong sustainability emphasises that social and ecological elements are complementary but not interchangeable (Ekins et al., 2003). However, resilience theory places equal importance in human and environmental elements in social-ecological systems in order to ensure their adaptability to changing conditions. It is this aspect of adaptive capacity therefore which measures the *resilience* of a given system (Berkes et al., 2003). Conversely, *strong* sustainability places the human within the natural realm and emphasises, in a very normative way, the conservation of the latter. Furthermore, both *weak* and *strong* versions of sustainability are aimed at the continuation of current levels of human welfare for future generations and, as such, hold a linear perspective maintaining current levels of human-environmental conditions. In a rather more intelligent way, modern interpretations of resilience since Holling (1973) incorporating non-linear and cross-scale transformations, in opposition to its *engineered* forerunner, place emphasis on the ability to adapt to *change* rather than to prevent degradation at all costs. Efforts have been made to relate, integrate and delineate the two subjects with varying success (e.g. Folke et al., 2002; Fiksel, 2006; Jahn et al., 2009). The importance which *strong* sustainability gives to natural systems as the source of all forms of capital has been adopted and described more explicitly by the Ecosystems Approach and the now popular framework of *ecosystem services*.

Against the backdrop of scientific developments concerning ecosystem resilience and the subsequent re-appreciation of the social-ecological nature of environmental processes, a view of natural resource management with human well-being as the explicit goal has resulted in the 12 principles of the Ecosystem Approach (CBD, 2001).

These 12 principles are:

Principle 1: The objectives of management of land, water and living resources are a matter of societal choices.

Principle 2: Management should be decentralized to the lowest appropriate level.

Principle 3: Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems.

Principle 4: Recognizing potential gains from management, there is usually a need to understand and manage the ecosystem in an economic context. Any such ecosystem-management programme should:

Principle 5: Conservation of ecosystem structure and functioning, in order to maintain ecosystem services, should be a priority target of the ecosystem approach.

Principle 6: Ecosystem must be managed within the limits of their functioning.

Principle 7: The ecosystem approach should be undertaken at the appropriate spatial and temporal scales.

Principle 8: Recognizing the varying temporal scales and lag-effects that characterize ecosystem processes, objectives for ecosystem management should be set for the long term.

Principle 9: Management must recognize the change is inevitable.

Principle 10: The ecosystem approach should seek the appropriate balance between, and integration of, conservation and use of biological diversity.

Principle 11: The ecosystem approach should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices.

Principle 12: The ecosystem approach should involve all relevant sectors of society and scientific disciplines.

(Source: CBD, 2004)

The focus on the value of natural resources towards human well-being has grown out of the increasing acknowledgement within related disciplines of the level of global environmental degradation which has taken place over the last 60 years (MEA, 2005). The MEA synthesis report underlines the rise of anthropogenic influences on the natural environment which led to greater changes in ecosystem function during the second half of the twentieth century than any other period in history (MEA, 2005). Such change has been associated with unprecedented levels of biological diversity loss (Foley et al., 2005). The report states that the greatest driver of change has been the increased demand for certain ecosystem services; namely: food, fuel, timber, fibre and water (MEA, 2005). In particular, the conversion of land



to agriculture is highlighted as the major driver of land-use change. Given that agriculture accounts for 70% of global water demand (MEA, 2005) as well as the spread of high levels of biologically available nitrogen (Howarth, 2008), the influence of food cultivation in ecosystems degradation is complex and severe. With ever increasing global demand for agriculture resulting from rising population levels, sustainable routes to food production have become one of the major focuses of social-ecological research concerned with human and environmental well-being (Powlson et al., 2011; Beddington et al., 2011; 2012; Wright, 2009).

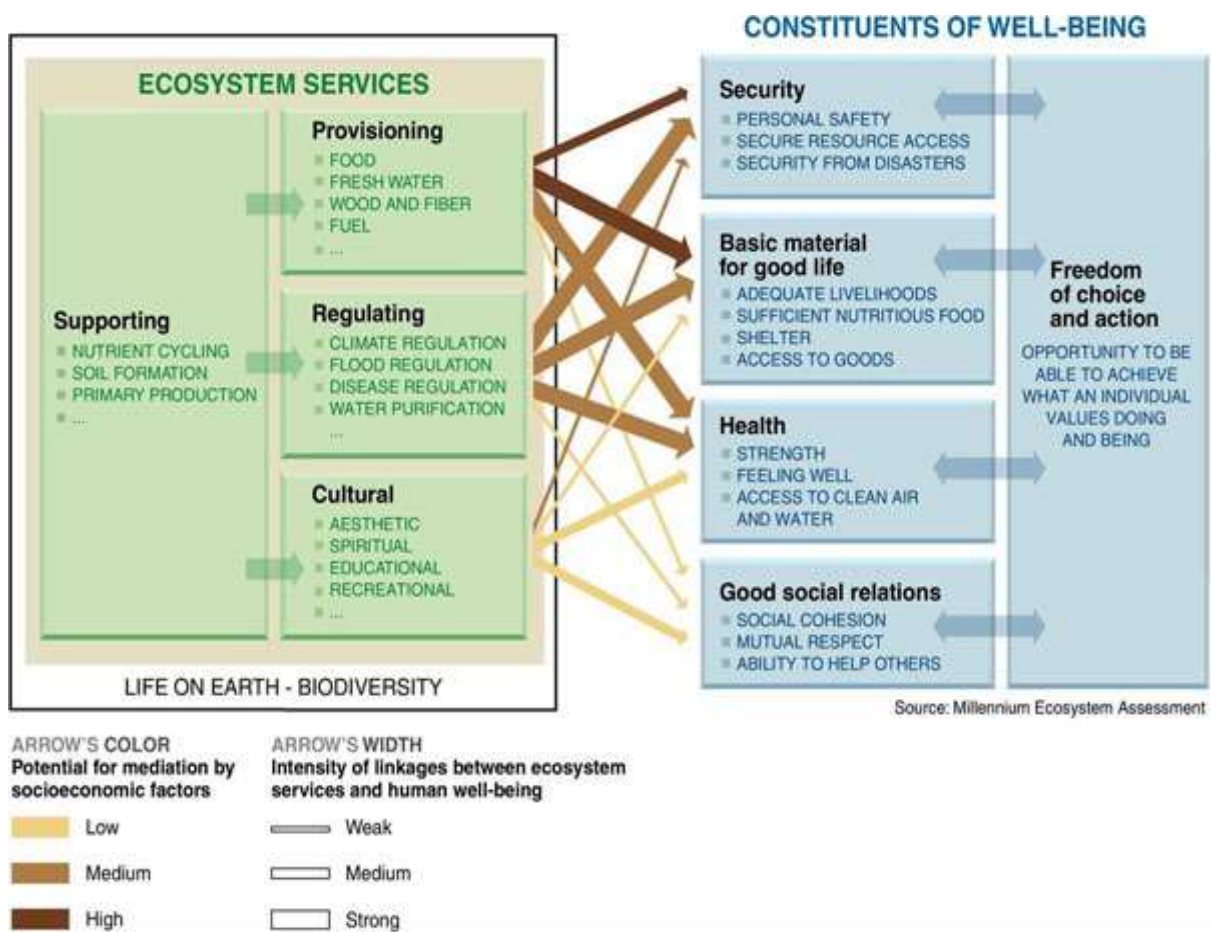
Initially outlined in the Convention on Biological Diversity in 2001, the Ecosystem Approach was taken up by the Millennium Ecosystem Assessment Report (2003) which particularly emphasised the importance of “ecosystem services” for human well-being (Principle 5 of the Approach). The Convention on Biological Diversity 2001 defines the approach as: “A strategy for the integrated management of land, water, and living resources that promotes conservation and sustainable use. An Ecosystem Approach is based on the application of appropriate scientific methods focused on levels of biological organization, which encompass the essential structure, processes, functions, and interactions among organisms and their environment. It recognizes that humans, with their cultural diversity, are an integral component of many ecosystems” (CBD, 2001. p.566). The latter insistence on the role of humans as an inherent part of the ecosystem illustrates how ideas drawn from models of social-ecological systems and adaptive capacity share, in theory, some common conceptual ground with the Ecosystem Approach. Likewise, a common insistence on the need to understand cross-scale effects and non-linearities within and across ecosystems is another area of overlap in these management strategies. Attempts to apply the Ecosystem Approach to urban areas have accordingly asserted the inseparability and complexity inherent in coupled human-environmental systems (Srinivas, 2003). Such systems approaches to the management of urban areas, such that put forward in the United Nations University Institute of Advanced Studies report on the subject (Piracha and Marcotullio, 2003), have borrowed from established concepts stemming from research into social-ecological systems and resilience thinking. The latter work emphasises flexibility in face of uncertainty, adaptive management and integrated, multi-scale governance. Such notions issue from an adaptive systems view of ecological resilience as developed in Holling’s seminal 1973 work on the subject and the associated body of theory which has subsequently

developed (Holling, 1978; Berkes and Folke 1995; Gunderson et al., 1995; Berkes et al., 2000; Gunderson, 2001; Holling, 2001).

Resilience theory may therefore be the more established and extensive tool in terms of conceptualising and understanding transformation, adaptation, and thresholds in social-ecological systems, as well as providing pertinent case studies (Folke et al., 2002; Walker et al., 2002; Janssen et al., 2006; Walker et al., 2006). The Ecosystem Approach, although integrative in style is largely normative in the promotion of such integration towards ecosystem management (CBD, 2008). The theoretical framework of resilience as applied to an adaptive social-ecological systems model, is arguably the more developed and scientifically implemented of the two. Resilience theory has, thereby, developed a more sophisticated array of concepts to cognise and unpack the various interacting elements within social-ecological systems. Such notions include social-ecological memory (Barthel et al., 2010), adaptive cycles (Holling et al., 2002), system traps (Carpenter and Brock, 2008), regime thresholds (Folke et al., 2006), social-ecological innovator networks (Moore and Westley, 2011) and delineating discrete types of cross-scale effects (Gunderson and Holling, 2002). However, Principle 5 of the Ecosystem Approach, specifically the promotion of the concept of ecosystem services, provides a practical framework for assessing, quantifying and valuing vital ecosystem processes which, within purely theoretical approaches to ecosystem management has been fundamentally lacking.

In the MEA (2005), ecosystem services are divided into four categories: provisioning services, providing direct concrete goods such as wood or food; regulating services towards flood prevention, climate control, or water quality; cultural services, the less tangible recreational, educational, or spiritual benefits; and supporting services in the form of primary production, nutrient cycling, and soil formation. Other versions of the framework have offered alternative classifications such as that outlined by The Economics of Ecosystems and Biodiversity initiative which re-classified *supporting* services as *habitat* services (TEEB, 2008). Similarly, the Common International Classification of Ecosystem Services recognises three outputs provisioning, regulating and cultural ecosystem services (Haines-Young and Potschin, 2013). In this classification supporting services are not acknowledged as a direct-use output but as those underlying ecological functions that are best managed from an alternative perspective (Haines-Young and Potschin, 2013). Essentially, however, all interpretations of the concept of ecosystem services build on the original framework set out

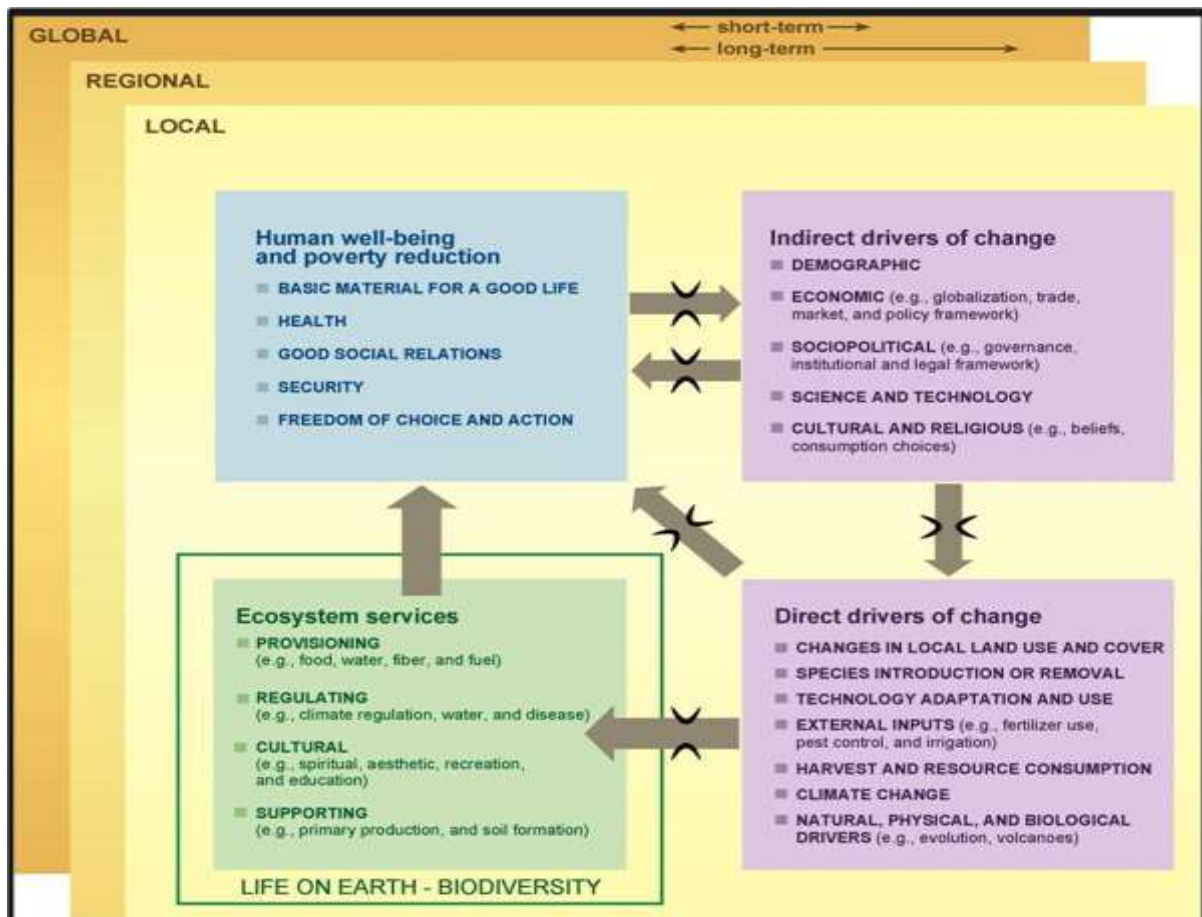
in the Millennium Ecosystem Assessment (2005), including the 2011 UK National Ecosystem Assessment. The principle objective of identifying and managing ecosystem services has been to ensure and enhance human health and well-being (MEA, 2005, de Groot et al., 2002) and the literature is growing rapidly in efforts to understand (e.g. Constanza, 2007), value (e.g. Tyrvaenen, 2001; Constanza, 2006), manage (e.g. Daily, 2009; Hancock, 2010), enhance (e.g. Defra, 2010c), and consolidate (e.g. de Groot et al., 2002) ecosystem services across the various classifications. Figure 2.4 shows the framework as outlined by the Millennium Ecosystem Assessment report.



**Figure 2.4 Millennium Ecosystem Assessment of services to well-being (MEA, 2005).**

The ecosystem services framework (Ecosystem Approach principle 5), coming from a value-based, utilitarian viewpoint, differs from both resilience (being primarily theory driven) and sustainability (being primarily policy driven). Whereas the latter two are chiefly concerned with scientific theory and adaptability, and political and behavioural change respectively, the chief concern of ecosystem services is the practical, experiential nature of our relationship to the environment with the aim of improving that relationship for human well-being. It can, therefore, be stated that the ecosystem services framework (Principle 5 of the Ecosystem

Approach), particularly with reference to the urban environment, constitutes an approach which is often focussed on the short-term, is practical/value based (de Groot et al., 2010), and place-specific (Barthel et al., 2010). It is concerned with the direct and indirect drivers of change and supporting conditions which affect the provision of ecosystem services for human well-being. The approach also acknowledges the cross-scale, cyclical nature of such processes as represented in Figure 2.5 which also appears in the MEA Synthesis Report (2005).



**Figure 2.5 Cycles and drivers of change in ecosystem services (MEA, 2005).**

Although Figure 2.5 suggests that the four key elements in the cycle occur across physical and temporal scales, the nature of cross-scale interactions and key ingredients for adaptive management thereof is not detailed. In the context of urban areas, the framework is concerned primarily with the receipt of goods and services provided by green space upon which urban residents depend in terms of both direct and indirect use. Therefore, to a large extent, the focus is in the short-term, on the preservation of the conditions which ensure the production of ecosystem services. This stands in contrast to the resilience-based approach

which primarily takes a medium to long-term view and is concerned with theory, adaptation and learning (Gunderson and Holling 2002). It generally looks at a larger geographical area and takes a regional stance to resource management (Lebel et al., 2006; Natural England, 2014). In turn, the ethos of sustainability has garnered an approach which is long-term, concerning “future generations” (WCED, 1987), is politically engendered and, as such, policy driven (e.g. WCED, 1987; ODPM, 2003; 2005; Sustainable Development Commission, 2007, 2008, 2010).

Whereas the ecosystem services framework and resilience theory are pragmatic and adaptive, respectively, sustainability is largely normative in its approach and is global in its perspective and aspiration.

From the point of view of social-ecological systems in urban areas, the enhancement of ecosystem services can often be influenced by the innovation of groups of individuals (Pudup, 2008), whereas resilience is based on the adaptability exhibited by a network of social and ecological actors (Anderies et al., 2004; Janssen et al., 2006) in the wider urban landscape. Sustainable development on the other hand looks at the conservation of essential resources into the future by influencing policy and through the tenet of the “ecological citizen”. Increasingly sustainability in urban areas has focussed on the promotion of sustainable communities (Campbell 1996; Haapio, 2012), one of the hallmarks of which is the increased participation in local environmental planning and decision making (Street, 1997; Tweed and Sutherland, 2007). Much like the broader term of sustainability however, sustainable communities can take on different meanings for different people and the term is often qualified and defined according to the socio-geographic context of its usage (Reed et al., 2006). The largely normative tenets of the original notion of sustainability remains in this localised version and accordingly, ideas around sustainable development seem to pervade modern life across all scales of activity, not least in urban areas as home to the majority of the world’s consumers. From an urban social-ecological perspective, where the local production of ecosystem services contributes directly to quality of life factors (Bollund and Hunhammar, 1999) and where innovation can play a mediating role in natural resource management (Ernstson, 2010) these three frameworks can be summarised as in Table 2.1.

**Table 2.1 Approaches to natural resource management.**

<b>Ecosystem Services</b>	<b>Resilience</b>	<b>Sustainable Development</b>
Short-medium term	Medium-long term	Long-term (generations)
Value-based	Theory-based	Policy-based
Pragmatic	Adaptive/learning	Normative
Place-specific/local	Regional/system	All scales/global
Intervention	Adaptation	Conservation
Group	Network	“Ecological Citizen”

Clearly there are many overlaps not displayed in Table 2.1 and it is more the case that the three approaches represent a sort of managerial panarchy where at different times and in different contexts one approach can take saliency over another as required (although this level of integration is, as yet, rarely put forward in practice). Furthermore, there are always exceptions to the above, particularly involving environmental processes at larger scales. The Millennium Ecosystem Assessment (MEA, 2005) gives a pertinent example of cross-scale effects where an international demand for timber leading to a regional loss of forest cover, which increases flood magnitude along a local stretch of a river, thereby resulting in service degradation for local people. Similarly, the protection of our ecosystems (and therefore the services they provide) relies heavily on our application of the “long-term” tenets of sustainability in order to ensure the continuation of those services. Likewise, the degradation of ecosystems due to unsustainable use can lead to non-linear changes which we can only hope to understand through the help of resilience theory. In this way the three approaches are necessarily complementary.

Nevertheless, each one offers a unique view on the management of natural resources and it can be said that these three core management practices have emerged as a result of efforts to optimise, manage, and sustain a healthy relationship between people and the natural environment. The ecosystem services framework, as defined by the Millennium Ecosystem Assessment (MEA, 2005), attempts to optimise our relationship with nature for the sake of the services which we can thereby derive and to protect natural assets. Secondly, resilience (after Holling, 1973) is an ecological concept which has expanded to lend itself to almost any conceivable system and attempts to manage the integrity of systems in the face of uncertain future change (Gunderson and Holling, 2002). Thirdly, sustainability champions thoughtful

consumption and the precept of “ecological citizenship” (Seyfang, 2006) as a means to sustain a healthy relationship with the planet for generations to come (WCED, 1987). Alternatively, the ecosystem services framework brings a pragmatism and focus on human well-being which seems irresistibly relevant and yet few examples of a concrete approach for local and regional planners, particularly in the case of urban areas, appear to be forthcoming. Recently, the ecosystem services framework has been adopted and cited in both government white papers (Defra, 2011; 2014) and initiatives by local authorities (Birmingham City Council, 2013). Similarly, Natural England has presented guidance for the protection and enhancement of ecosystem services for planners and partners in principally rural areas (Natural England, 2014). However, such policies and guides fail to address the cross-scale reality of urban social-ecological systems (Ernstson et al., 2010).

The ecosystem services framework, if employed intelligently and applied in conjunction with the wider, more holistic tenets of the Ecosystem Approach (incorporating all 12 principles) or with a resilience thinking approach could be a powerful tool for measuring and ensuring desirable ecosystem function into the future.

## **2.4 The rise of the ecological citizen**

In the face of global and local environmental degradation and political uncertainty, how can the well-meaning individual be assured they are contributing to the solution rather than the problem? The pseudo-ethical concept of the ecological citizen has been the subject of much scrutiny by social and environmental scientists and is a theoretical as well as a practical link between the three management approaches described above. This endeavour stems back to the work by the social scientist Sagoff (1988) who attempted to clearly delineate the two roles of “citizen” and “consumer” carried out by humans in society. This rather simplistic view of the ecological citizen has been recently overturned. In the same vein that the interconnectedness of the social and ecological sciences are being recognised, Dobson (2003) has postulated the simultaneity of the private and political behaviour of humans, as embodied by the entity that is the ecological citizen. It has been equally validated by NGOs as well as government-led initiatives (Defra, 2003b; Seyfang and Smith, 2007) aimed at local and global environmentally responsible behaviour through education and incentivisation aimed at reducing the ecological footprint of individuals and nations.

The impetus for locally-driven change had been particularly emphasised in the UK with the promotion of The Big Society agenda and subsequent devolution of public services (Cabinet Office, 2013) by the Coalition government. The aim of this policy is to shift practical responsibility for services, including those which enhance and protect the natural environment, away from central government and towards individuals, businesses, civil society organisations, and local authorities (Defra, 2010b). The first word on the list of these new decision makers, and no doubt a reflection of its primacy, is *individuals* and the new, dual private-public role of the individual is epitomised in such terms as “global citizen” and associated slogans such as “act locally, think globally”. Seyfang (2006) has questioned the apparent oxymoron present in such maxims and asks if “localism” and “globalism” are, in fact, aligned or contradictory concepts. Although the jury is still out on this subject, the moral of the “ecological citizen” has received further criticism from Maniates (2001), who claims that the whole notion is an attempt to “individualise” the responsibility for environmental degradation and reduce the perceived culpability of larger corporations and governments. Presumably “The Big Society” policy would no doubt be an example of a move in this direction. Furthermore the same author holds up the concept of the “green consumer” as another irreconcilable paradox and, at least to some extent, as a commercial ruse to glean revenue off the back of the increasingly challenged social conscience of the ecological citizen. The result of such an endeavour, says Maniates (2001), is to actually increase rates of commercial consumption, effectively sacrificing true sustainable development at the altar of ethical consumerism.

Further doubts surrounding the sanctity of the ecological citizen have been exposed with reference to the irrationality inherent in human decision making (Kumar and Kumar, 2008) and the divergent ways in which humans view the natural world. The latter are outlined by ideas such as the Hierarchist-Egalitarian-Individualist paradigm put forward by Thompson and Raynor (1998) and taken up by Gundersson and Holling (2002) in their seminal work on panarchy. Here the authors place great emphasis on the attitude of people towards the planet, and their view of mankind’s place in the natural order, when considering human behaviour and, ultimately, the destiny of social and global ecological systems.

Notwithstanding the complexities inherent in global political ecology and the shortcomings of the concept of ecological citizenship, it can be said that people, as individuals or groups of individuals, hold increasing influence over the future of ecosystems whether the concern is



for services, resilience or sustainability. An appreciation of the role of individuals and groups as environmental actors has been acknowledged in the UK National Ecosystem Assessment (2011). The recommendations of the UK NEA (2011) called for increased promotion of stakeholder participation, collaboration between social-ecological actors, and the provision of environment-based education. Such measures should contribute to the flexible, adaptive management of ecosystem services across physical and temporal scales. Nowhere is such an adaptive approach to ecosystems management more pertinent than in today's most modified landscape, the centre of human knowledge and decision-making, and now home to most of the world's "individuals": the urban environment. Here, the ecological citizen finds him/herself at the centre of a global community whose actions have both causes and effects at various scales. As such, actors within urban areas are presented with significant challenges and, therefore, opportunities for the creation of new innovative, collaborative approaches to natural resource management in human-dominated ecosystems.

## **2.5 The ecology of urban areas**

Although a recently evolving discipline, the interest in and concern over urban ecology is not a new one. Young (2009) attempts to point out the forgotten heritage of urban ecologists in the work of Alexander von Humboldt (1769-1859), Frederick Law Olmsted (1822-1903), Ebenezer Howard (1850-1928), Patrick Geddes (1854-1932) and Robert Park (1864-1944). Young (2009) suggests that modern urban ecologists should determine to gain from the rich intellectual heritage established by these men of science and that their work is as relevant today in that it "sought to explore from various vantage points both concrete strategies for resolving the negative aspects of urbanisation, and a view unifying social and ecological systems." (p. 327).

Modern attempts at bringing ecology into the urban setting have often centred on singular observable factors such as the effect of human disturbance on species diversity (Alberti, 2005). Other work, taking a landscape approach to the subject, focusses on land use patterns and the spatial heterogeneity that can be observed across most urbanised areas (Pickett et al., 2001; Breuste et al., 2008). Small-scale studies have highlighted physical trends such as the urban heat island phenomenon (Oke, 1995), soil modification (Effland and Pouyat, 1997) and pollutant levels (Lovett et al., 2000). Ecological studies are hierarchical by

nature and although isolated small-scale studies may reveal the dynamic and the unpredictable, larger scale (geographic and temporal) studies have suggested characteristic ecological assemblages within cities (Pickett et al., 2001). More progressive research has emphasised the role of urban ecosystems and the effect of increasing urbanisation on such ecosystems, and their importance for the quality of life for people living in cities. Bolund and Hunhammer (1999) stated that although all people regardless of whether they live in urban or rural areas are dependent on global ecosystems “The quality of life for urban citizens is improved by locally generated services, e.g. air quality and noise levels that cannot be improved with the help of distant ecosystems.” (p. 8).

The evolving discipline of urban ecology has described the complex nature of the urban environment and some work has been done to appreciate the relative value of ecosystem services within cities (e.g. Tratalos et al., 2007, Williams et al., 2009). The authors of the Millennium Ecosystem Assessment (2005) chose largely to ignore the urban landscape whereas the World Development Report (World Bank, 1996), while focussing on urban areas, did not touch upon the subject of ecosystems in any form. A better appreciation of environmental change and the social innovations occurring within cities would go some way to lessen the gap in our knowledge.

Increasingly, emphasis has been placed on the high complexity of social-ecological systems found in cities and urban environments (e.g. Norberg, 2008; Barthel et al., 2010). Although “normal” ecological concepts such as succession, competition, resilience and evolution may have certain parallels in the urban environment (Odum and Barrett, 2005), the inherently social dimension of cities tends to complicate if not subvert such models (Gould, 2002). Nonetheless some consensus has been established over certain essential priorities for urban security and prosperity. Namely, the provision of important ecosystem services (CBD, 2000), effective resource management dependent on information networks (Bodin and Norberg, 2005), adaptive management towards future resilience (e.g. Wallington et al., 2005), sustainable, understanding of multiple-scale ecological relationships (Gunderson and Holling, 2002) and the promotion of local social-ecological memory (Barthel et al., 2010). The latter two are key elements in the systems model of panarchy (Gunderson and Holling, 2002) and Holling’s description of adaptive cycles (Holling, 1996), and imply that there is also much that

can be learned from these theoretical perspectives when attempting to understand urban social-ecological systems processes.

## **2.6 The reciprocity of human and environmental health in urban areas**

The Ecosystem Approach as asserted in the Millennium Ecosystem Assessment places great emphasis on the link between ecosystem services and human well-being and this parallel of human and environmental health is echoed by findings in the scientific literature (e.g. von Shirnding, 2002; European Commission, 2003; Burls, 2005; Pudup, 2008).

Urban areas are incredibly dynamic, modified socio-physical landscapes and as such bring with them heightened levels of social, environmental, and health-related stresses. These can be summarised accordingly (Commission for Architecture and the Built Environment, 2010; Coutts, 2010):

1. Social: lack of safe, accessible communal and recreational spaces; high crime rates; and increased deprivation.
2. Health-related: increased levels of pollution; poor diet; stress; heightened anxiety; little access to outdoor activities; and lack of natural, open spaces.
3. Environmental: loss of biodiversity; land contamination; flood risk; high ecological footprint; climate change; and food security.

These factors are interrelated with each one reflecting the other two. So aligned are human and environmental health in the urban setting that they are being increasingly viewed as synergistic, reciprocal phenomena (MEA, 2005; World Health Organisation, 2005; Coutts, 2011). Not only do ecosystem services play a key role in human well-being in cities, it is also true that human behaviour at local scales affects the provision of and access to these services (Pudup, 2008).

In particular, UK government led research has been done into the effectiveness of combatting the stresses of urban living through access to quality green space (Marmot Review, 2010). The Depression Report by Lord Layard (London School of Economics and Political Science, 2006) states that loss of output in the UK due to depression and chronic anxiety was £12billion per year at the time of the report which amounted to 1% of the total national income. The national charity MIND claims that in 2005 there were 27.7 million prescriptions written for anti-depressants at a cost of £338 million to the National Health

Service (MIND, 2007). MIND has produced its own report “Eco-therapy” (MIND, 2007) on the effectiveness of physical activity in green spaces and is taking the lead on bringing eco-therapy into mainstream care provision for people suffering from physical and, in particular, mental distress. The research was undertaken by the University of Essex and demonstrated a significant decrease in levels of distress among participants involved in “green” (nature-based) activities as opposed to those undertaken in highly urban or indoor environments. Similar research has been undertaken in the Netherlands (de Vries et al., 2003) which demonstrated better physical and mental health among residents living in close proximity to green space than those in more highly urbanised neighbourhoods, and in Australia research has been undertaken which puts forward woodland management as an effective remedy for depression (Townsend, 2006).

## **2.7 Environmental accounting and applying the ecosystem approach in the UK**

The Ecosystem Approach was put forward and adopted as a lucid framework which seemed to suggest a practical and, where necessary, monetary approach to managing our ecosystems at various scales (MEA, 2005). Attempts have since been made to flesh out the promising conceptual elements of the Millennium Ecosystem Assessment into a working methodology for environmental accounting and management to enhance and protect global and local ecosystem services. Perhaps the most comprehensive of these has been The Economics of Ecosystems and Biodiversity (TEEB) study, a global-scale initiative that seeks to produce research on the economic and environmental costs of ecosystem and biodiversity degradation with the intention of informing decision-makers at all levels (TEEB, 2008). Research has been carried out along four main strands: i) studies focussing on individual countries for which TEEB profiles of 19 countries have so far been established, (2014); ii) studies which focus on economic sectors (such as agriculture and food); iii) on ecological biomes (such as oceans and coastal areas); and iv) TEEB studies for business aimed at informing business and enterprise at the national level. The TEEB initiative is married closely to the notion of natural capital and the use of economic methods and proxies to value and, thereby, manage ecosystem services more effectively and realistically. The designation of transferable economic values to natural resources is aimed at providing a working

appreciation of the role of such capital towards human well-being (Daly and Farley, 2004) and as well as functional valuation approaches to ecosystem goods and benefits (Costanza et al., 2006). In this respect, urban areas, largely due to their inherent complexity, have been continuously overlooked. The TEEB database compiled by van der Ploeg and de Groot (2010) has provided one of the few attempts to place a coherent value on urban green space. The latter provided a figure for total economic value based on proxies for climate regulation, recreation and water regulation though these values were derived from a single study (Brenner-Guillermo, 2007) which took a landscape-scale approach and thereby failed to acknowledge the complexity and multi-functionality of diverse urban green spaces. Studies which offer a detailed economic account of the functionality of the current array of urban green space types have not been forthcoming.

The TEEB profile for the United Kingdom was compiled in conjunction with the UK National Ecosystem Assessment (UK NEA) in 2011. The latter project built on the Ecosystem Approach set out by the MEA in 2005, was funded by Department for Environment, Food and Rural Affairs and sought to audit and categorise the services provided by the United Kingdom's terrestrial, freshwater and marine ecosystems (UK NEA 2011). The report also projected the state of the nation's habitats and ecosystem services based on a combination of different policy, behavioural and climatic scenarios. The main findings of the UK NEA as outlined in the Synthesis Report (UK NEA, 2011) include the need to sustainably intensify agricultural practices whilst aiming to reduce their carbon footprint and the importance of nature in the meeting of existence and value "needs" of human beings where contemporary consumption practices have failed. Again, interaction with and recreation in nature were highlighted in the report as significant contributors to human health and well-being. The UK NEA report states that "a key knowledge gap regarding education and ecological knowledge goods concerns the processes by which adults acquire ecological knowledge, their participation in nature-based educational activities and how knowledge acquisition is influenced by engagement with environmental settings as a form of cultural service." (UK NEA, 2011, p.83). Given that the report also highlights, and recommends, increasing public participation in the management of ecosystems, an understanding of the actual situation regarding the development and benefits of community-led ecological stewardship represents a contemporary research imperative.

With the widespread adoption of the Ecosystem Approach for environmental resource management there has been increasing acknowledgement of the need to understand and detail the potential for synergies and trade-offs in those ecosystem services which derive both from specific habitats and across scales (Foley et al., 2005; Bennett et al., 2009; Nelson et al., 2009; Maes et al., 2012; Mouchet et al., 2014). Consensus has been reached that stipulates the advantageousness of approaching ecosystem management in a way which honours the multiplicity and complexity of multiple-service production (Norgaard, 2010). Such an approach typically champions the co-management of a range of services referred to as “win-wins” (e.g. Howe et al., 2014) or “bundles” (e.g. Raudsepp-Hearne et al., 2010). As such, detailed knowledge of the mechanics of actual service provision by real life cases is essential, particularly in urban areas and at scales below the landscape level (UK NEA, 2011), in order to gain an accurate understanding of the interplay between elements contributing to ecosystem services in highly complex social-ecological systems. Haase et al. (2012) have described trade-offs, synergies and losses in the production of a range of urban ecosystem services over time. Although such studies document relationships between services at the landscape scale, a better appreciation of on-the-ground service production by, as well as the use and management of, green assets in urban social-ecological systems is still required.

## **2.8 Applying resilience theory to ecosystem services management**

As the concept of social-ecological systems has become increasingly accepted as a fundamental basis for understanding environmental process at local and global scales, resilience theorists have sought to integrate ecosystem services into a collective framework. Therefore, increasingly, resilience in social-ecological terms has come to be qualified as the resilience *of* ecosystem services *to* changes in system dynamics. Such work has thereby enabled a synthesis of the theoretical power stemming from a resilience approach to studying adaptive systems (Berkes and Folke, 1998; Walker et al., 2006) with the practical, value-based strengths of the ecosystem services framework (MEA, 2005). The former offers a level of sophistication in unpacking complex social-ecological systems which has been applied to a variety of cases (Folke et al., 2002; Janssen et al., 2006; Walker et al., 2006) but which has not yet been convincingly exhibited by the latter. That said, the concept of ecosystem services has been widely adopted by local and national government bodies

(Defra, 2011; Birmingham City Council, 2013; Defra, 2014; Natural England, 2014). A synthesis of these two approaches may facilitate a richer, more empirical method to designing and measuring sustainable urban ecosystem management. In so doing, the possibility of increasing the body of quantitative research-based case studies into urban social-ecological resilience as well as providing opportunity for empirical but holistic studies of urban ecosystem services is married. A key subject of overlap across the two frameworks is the mutually acknowledged importance of innovation in the management of ecosystem services and the generation of adaptive capacity. Accordingly, the role of social-ecological innovation offers a pertinent opportunity for exploring the twin issues of adaptive capacity and productivity of urban green space management as well as adopting the latter two criteria in an evaluation of the desirability of such innovation.

Biggs et al. (2012) identified seven core principles of the resilience approach which, if applied, lead to the optimal adaptive management of those valuable ecosystem services provided by social-ecological systems. These suggested principles are:

1. Maintaining diversity and redundancy
2. Managing connectivity
3. Management of slow variables and feedbacks
4. Foster understanding of social-ecological systems as complex adaptive systems
5. Encourage learning and experimentation
6. Broaden participation
7. Promote polycentric governance systems

(Biggs et al., 2012)

The first principle highlights the importance of diversity and functional redundancy in the system in order to ensure response diversity in the face of system regime change. However, such diversity and redundancy, whilst contributing to long-term adaptive capacity can lead to short-term costs in efficiency. It is important, therefore, that a balance of the two is achieved as very high levels of diversity and redundancy can lead to undesirable levels inefficiency in the production of ecosystem services.

The second principle identifies the need for connectivity between nodes in the social-ecological system for the distribution of knowledge and effective collective response to change. Again, a balance is necessary as very densely connected social networks can, for

instance, lead to the homogenisation of knowledge and practices, thereby reducing response diversity.

The management of slow variables and feedbacks involves mapping key ecosystem functions, interactions and desirable feedbacks that underpin or provide buffers of protection to ecosystem services. Identifying the thresholds within which they function is crucial in order to manage their continuation into the future.

An understanding and acknowledgement of social-ecological systems as complex and adaptive (principle four), at various levels of governance, is vital. Such an understanding of the complexity of system interactions should be adopted by decision makers, managers, actor groups and local stakeholders. Of particular importance is a move away from traditional notions of engineered resilience and the investigation of non-linearities in system dynamics.

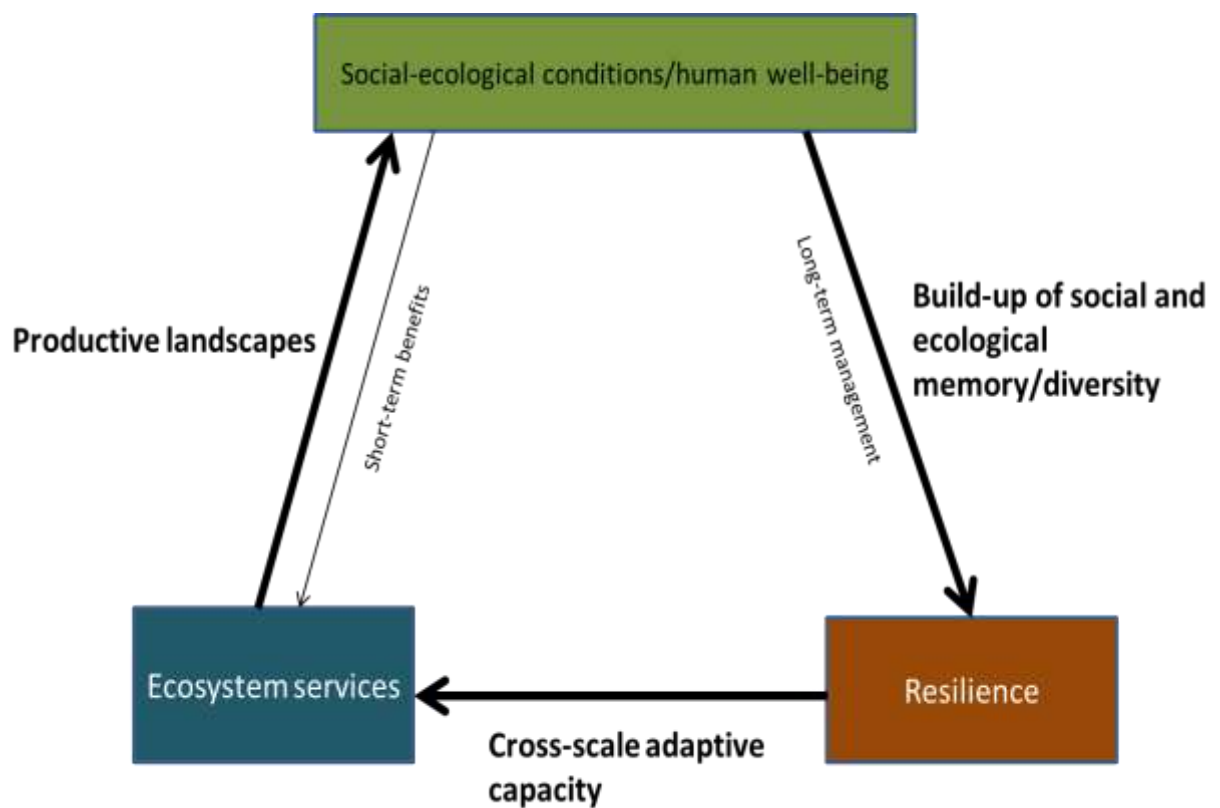
Principle five promotes the need to facilitate knowledge sharing and continuous learning among actor groups and the establishment of suitable forums for the distribution of knowledge and resources.

The sixth principle underlines how the participation and engagement of all relevant stakeholders in the social-ecological system increases trust, cooperation and knowledge legitimacy.

Finally the seventh and overarching recommendation is for the adoption of polycentric models of resource governance not only to ensure response diversity but to facilitate the successful wider promotion of other key principles in this list.

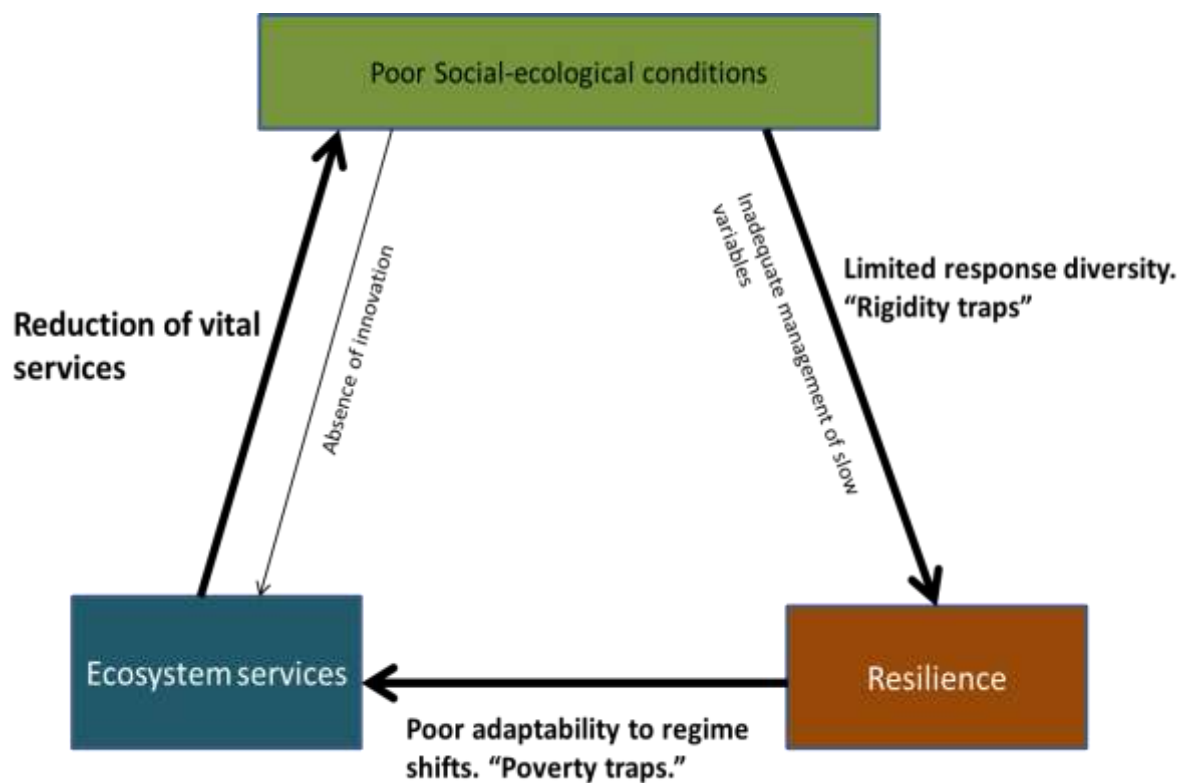
These principles consolidate the main features of the theoretical model behind the adaptive management approach to complex systems and provide one framework for uniting the interrelated management imperatives issuing from resilience theory, the ecosystem services framework and sustainability. Although each of these management frameworks has advantages and shortcomings in their outlook, effective delivery of conditions necessary for human well-being must seek to integrate the physical and temporal scales which these three address. Particularly in urban social-ecological systems, which represent the most complex human-nature relationships, for communities and ecosystems to be sustainable, the interconnectedness of social-ecological conditions, adaptive capacity and ecosystem services must be acknowledged. This interconnectedness is theorised in Figure 2.6





**Figure 2.6 Interconnectedness of social-ecological conditions, resilience and ecosystem services in sustainable social-ecological systems.**

Figure 2.6 presents a model of the cyclical relationship between social-ecological conditions, resilience and ecosystem services in human-modified systems. In essence, each of the three aspects is dependent upon the other two and the flow of energy has the potential to generate positive feedback loops. Pre-existing social-ecological conditions provide the potential for social-ecological memory, biological and cultural diversity, and innovation which contribute towards system resilience. The latter in turn delivers long-term adaptive capacity in the face of regime fluctuations which facilitates continued production of vital ecosystem services. These accordingly ameliorate social-ecological conditions, elements of which may provide further social-ecological memory towards increased adaptive capacity. Figure 2.6 generalises such positive feedbacks although, conversely, negative cyclical trends may develop from poorer pre-existing background conditions where the desired social-ecological capital is lacking. These are represented in Figure 2.7.



**Figure 2.7 Negative feedbacks in resilience, ecosystem services and social-ecological systems.**

Although the linked elements within this theoretical framework are interdependent, baseline social-ecological conditions represent the pivotal aspect of the management framework. This background context comprises simultaneously the primary cause and effect in the cycle, embodying both the means and the end of managing for sustainable social-ecological systems. Furthermore, beneficial social-ecological conditions, as well as providing the opportunity for increasing system resilience, also involve direct feedbacks in terms of ecosystem services. The latter is the primary source of human well-being (MA, 2005) in all social-ecological systems and, in the urban environment, such services are often sequestered from distant ecosystems. That said, social-ecological management within those systems, such as re-designation of public green space types, tackling environmental injustice, as social interventions (Boone et al., 2009) and ecological measures such as afforesting programmes or use of irrigation systems (Bastian et al., 2012; Pataki et al., 2011) can also harness productivity issuing from fast variables in existing ecosystem services. Additionally, background social-ecological processes influence both adaptive capacity and urban ecosystem services across scales. At local spatial and temporal scales benefits and services are provided by elements of green infrastructure such as public park provision, street trees

and urban forests whilst slower ecological variables such as soil processes, biodiversity loss and sea-level changes, operating at larger spatial and temporal scales, dictate the boundaries within which local social-ecological conditions remain viable. In order to address such cross-scale processes, effective resource management and innovation in social-ecological systems must seek to simultaneously deliver ecosystem services whilst finding positive feedbacks which lead to improved adaptive capacity. Furthermore such measures should address cross-scale effects where slow controlling variables are managed sustainably and the resilient management of faster, local variables is ensured through response diversity and functional redundancy in the landscape. Polycentric governance which encourages stakeholder participation and promotes local innovation based on social-ecological learning may comprise an effective element in such adaptive management as stipulated in the principles set out by Biggs et al. (2012) and Ernstson et al. (2010).

## **2.9 Modern social-ecological challenges and urban areas**

Research into social-ecological initiatives, especially in urban areas, with innovative approaches to green space management offers insight into the acquisition of ecological knowledge. The benefits of initiatives involving inclusive, stakeholder-led management of urban green space have been clearly asserted in the literature (Barthel et al., 2010; Ernstson et al., 2013) but as yet little work has been done to delineate the specific ecosystem services provided by such programs. Neither has there been any attempt to identify synergies and trade-offs between ecosystem services related to such innovative forms of green space management and with others relevant to the urban environment. Accordingly, the need for an increase in the body of research into ecosystem services production and associated trade-offs in urban areas was one of the key findings of the UK NEA (2011). Furthermore, types of social-ecological practices vary according to the context, management and remit of diverse communities. The specific social-ecological circumstances of management innovations may or may not have a significant bearing on their output in terms of ecosystem services. The results of such study will have relevance in countries across the world as innovative practices develop that seek to address the challenges of the 21st century.

Of the challenges, three environmental trends are of primary significance to human and environmental systems: i) climate change, ii) population change and iii) land use change.

Urbanisation plays a key role in all three of these processes, with the urban environment, and those to whom it is home, situated at the nexus of the interaction between these interrelated trends (Carlson and Arthur, 2000; Kalnay and Cai, 2003; Verburg et al., 2010; Lambin and Meyfroidt, 2011). These three concerns are inexorably linked as increasing global population levels demand greater areas of land for housing, agriculture and other resources. Urban areas are conspicuous in this complex system as home to the majority of the world's consumers, with cities often carrying an ecological footprint that in some cases can be up to a thousand times that of its physical area, relying principally on the services of external ecosystems (Folke et al., 1997). Furthermore, 78% of global carbon emissions derive from the world's cities (Grimm et al., 2008).

Land use change due to urbanisation can result in high extinction rates for native species (Kowarik, 1995; Marzluff, 2008), with lasting consequences not generally witnessed for other land use change scenarios (Stein et al., 2000). Urban areas generally contain poorer species richness and diversity across all taxonomic groups (Mckinney, 2002; Kuhn and Klotz, 2006; Aronson et al., 2014). Moreover the process of urbanisation can often be catastrophic for species assemblages, the resulting land-use types suiting non-native, generalist varieties (DeCandido et al., 2004; McKinney, 2006; Pauchard and Shea, 2006). Biodiversity loss is incurred at local, regional and global scales due directly and indirectly to human-induced urban sprawl (Grimm et al., 2008). Urban resource demand due to population growth, particularly for agriculture, also has far-reaching impacts on climate change scenarios (Satterthwaite, 2009). Associated with increasing population and urbanisation is the rise in surface sealing and infrastructure in the form of road and other transport links. Such increases in impervious surfacing not only reduces ecological functions such as soil formation and water attenuation (Ellis et al., 2006) but such infrastructure has a deleterious effect on biodiversity. At the local level, high disturbance has the effect of reducing biodiversity levels across a range of taxa (Alberti, 2005) and associated emissions, chiefly atmospheric nitrogen deposition, lead to ecosystem degradation at both local (Stevens et al., 2004; Elser et al., 2007) and global scales (Zavaleta et al., 2003; Bobbink et al., 2010; Pereira et al., 2010).

Not only do cities appropriate vast ecological resources at local and global scales, but the distribution of those resources within the urban region, tend to echo familiar patterns of socio-economic inequality among the population demography (Haughton, 1999). Such

inequality is often characterised by the differential access to quality environmental resources and amenities according to racial or socio-economic group (Schweitzer and Stephenson, 2007). The production and distribution of urban ecosystem services has likewise also been shown to be subject to similar patterns of inequality (Jeanerette et al., 2011; Farley, 2012) and in some cases mediated by socially derived area characteristics (Ernstson, 2013). However, the specific mechanisms by which such mediation occurs have not hitherto been adequately articulated, nor the social-ecological context of local, community-managed ecosystem services. Such stakeholder participation in urban social-ecological systems may prove to be pivotal towards future urban resilience (Biggs et al., 2012). One key area in which anthropogenic stewardship of natural resources requires careful planning towards the sustainable production of vital ecosystem services involves the management of the 38% of the Earth's terrestrial land-use devoted to agriculture (World Bank, 2015).

## **2.10 Food and the environment: an uncomfortable relationship**

The relationship between food production and climate change is complex and involves interrelated processes (Lal, 2004; Bruinsma, 2003; West and Marland, 2002). Since the beginning of the Holocene and the invention of agriculture and animal husbandry, humans have cleared increasing amounts of land to establish food security, much of it by way of deforestation. This has been the greatest driver of land use change in the current geological period and a major contributor to climate change due to the concurrent reduction in carbon sequestration associated with mass deforestation (DeFries et al., 2004; Kaplan et al., 2009). Furthermore the trend continues unabated with much of the Earth's remaining rainforest under threat from clearance for crop production, most of which is due to agricultural expansion (Tilman et al., 2011). The consequences of such levels of deforestation entail potentially hazardous climatic feedbacks (Coe et al., 2013). Agriculture as a practice also contributes to climate change through the release of soil organic carbon, methane from livestock, greenhouse gases from the use of fertilizers and fossil fuel emissions from industrial machinery (Lal, 2004). Much research has been carried out into the detrimental effects of climate change on agricultural systems and productivity in the face of rising global population (Adams et al., 1998; Fuhrer, 2003; Tubiello and Fischer, 2007; Falloon and Betts, 2010) though less emphasis has been placed in the literature on the inverse effect of

agriculture on climate change. It has been estimated that there will be a five percent loss in crop yield per degree Celsius in global warming that occurs (Lobell and Gourdji, 2012). Although the production of food through agriculture is necessary for human survival, research into food security, sustainability and environmental impacts has uncovered disconcerting realities associated with the global food system (McMichael et al., 2007). A report by the Consultative Group on International Agricultural Research found that the food industry (from production to consumption) accounted for between 19 to 29% of the global yearly total greenhouse gas emissions. Increasing intensification and use of synthetic fertilizer means agriculture is responsible for the majority of nitrous oxide emissions on the planet (CGIAR, 2015).

One attempt to reduce the carbon footprint of the food system has given rise to the idea of food miles. The idea of food miles as an approach to quantify the sustainability of the food industry has been adopted by governments (Rama and Lawrence, 2008), and NGOs, such as Sustain (Sustain, 2011), to explore the environmental and socio-economic benefits of reducing food miles through the localisation of the food system. The concept has equally received criticism in the literature however (Smith et al., 2005; Engelhaupt, 2008; Hogan and Thorpe, 2009), and research has shown emissions from the end-transport of food to contribute less than 5 percent of the overall GHG emissions from agriculture (Vermeulen et al., 2012). That said, local food systems have been shown to benefit local economies and to increase community resilience as well as food security (Schnell, 2013; Van Passel, 2010). Agriculture, whilst contributing to the environmental processes behind climate change, is also the key driver of global land-use change, and therefore bears a close and complex relationship with biodiversity conservation (Rey Benayas and Bullock, 2012). Not only is it the major source of deforestation globally (FAO, 2010), agriculture reduces habitat heterogeneity in the landscape (Benton et al., 2003) and the use of chemical pesticides and fertilizers leads to ecological degradation and species loss (Geiger et al., 2010; Potts et al., 2010). This precarious relationship is further stressed by the fact that agricultural systems themselves depend on agro-ecological diversity for their overall resilience (Altieri, 2004; Chappell and La Valle, 2009; Birch et al., 2011).

Whereas much debate has ensued over whether a land-sparing or land-sharing approach may be more beneficial for biodiversity conservation (Green, 2005; Phalan et al., 2011) recent work has highlighted that such a framework is guilty of oversimplification and does

not reflect the real life complexity of food poverty, traditional agro-ecological practices and land mosaic effects (Tscharnkte et al., 2012). The effects of agriculture on local and regional biodiversity is non-linear and is modified by farming practices and levels of intensity (Donald, et al., 2001; Bengtsson et al., 2005) where small-scale and organic approaches have been shown to be beneficial for biodiversity and, therefore, advantageous for long-term resilience and system response diversity (Crowder et al., 2010; Winqvist et al., 2011). Furthermore, smallholding approaches, as opposed to large-scale intensive farming methods, have been identified as a vital ingredient of global food security (Horlings and Marsden, 2011). This assertion has been supported by the revelation of paradoxical associations between decreasing farm size and increasing productivity, known as the “inverse farm-size productivity relationship” (Alvarez, 2004; Rios and Shively, 2006). Evidence of such trends have come largely from studies in developing countries but an appreciation of the benefits to food security and agro-ecological diversity by heterogeneous smallholding approaches in developed regions is yet to be detailed. Examples of small-scale, agro-ecological approaches to food production are being increasingly found in the world’s urban regions in a variety of improvised formats (Mbiba, 1995; Mougeot, 2010; Hardman, 2014).

## **2.11 Urban agriculture – a response to local and global stresses**

As mentioned, in preceding sections, agriculture as a practice and the associated global food system is a considerable contributor to the processes which are driving climate change and the principal cause of land use change by deforestation. However, on a local scale it has been suggested that novel, small scale approaches to agriculture in urban and peri-urban settings can bring social and ecological benefits (Zezza and Tasciotti, 2010; Ackerman, 2012; Lwasa et al., 2014). Urban agriculture (UA) is now a burgeoning area of study as examples of UA are observed in both developed and developing regions (e.g., Zezza and Tasciotti, 2010; Mawois et al., 2011; Zasada, 2011; Aubry et al., 2012; Baker 2012; Barthel and Isendahl, 2013; Colding and Barthel, 2013; Kulak et al., 2013; Lynch et al., 2013). Studies have demonstrated that localised urban and peri-urban food production systems can reduce greenhouse gas emissions associated with agriculture by a factor greater than those achieved through carbon sequestration by parks and forested areas, largely as a result of local knowledge and sensitivity to seasonal crop rotation (Kulak et al., 2013). Other outputs

from UA which can increase urban resilience, particularly in the face of climate change, include water attenuation (Aubry et al., 2012), alleviation of food poverty (Baker, 2012; Barthel and Isendahl, 2013; Lynch et al., 2013) and social cohesion (Colding and Barthel, 2013).

The necessity of planning for sustainable food systems, particularly as part of a wider vision to support urban resilience, is being acknowledged and promoted at local and national scales. A case in point is the Food Futures initiative launched by Manchester City Council in 2007 which aims to engage with businesses, stakeholders and other agencies to improve the living and working conditions for citizens and reduce environmental impacts caused by the food system. From this initiative several items of research were commissioned highlighting the economic, environmental and health-related gains that are to be made from moving to localised food systems which involve an integrated network of growers, public and private retailers, and community stakeholders (Kazmierczak et al., 2013; Berners-Lee et al., 2013). Urban agriculture also presents the opportunity to simulate, and reinstate to some degree, a relationship to nature - the loss of which has led, in recent years, to a disconnect between humans and the natural world with damaging consequences for human well-being, ecological knowledge and skills and environmental awareness (Defra, 2011).

Given the increasing practise and promotion of UA based on perceived benefits, the relationship between food production and ecosystem services in urban areas has not been fully explored and much of the evidence put forward in claims as to its efficacy is based on derived quantitative data (as opposed to data from empirical case studies), conceptual frameworks and qualitative studies (e.g. Zezza and Taciotti, 2010; Mawois et al., 2011; Zasada, 2011; Aubry et al., 2012). A body of empirical research investigating ecosystem services associated with urban agro-ecological practices and the social-ecological drivers, actors and networks in which they are embedded would invite more accurate discussion of the benefits of UA. Such an approach to researching the subject is, however, so far lacking.

## **2.12 The potential for self-producing urban areas**

One of the key messages of the UK National Ecosystem Assessment was the underlining of the need for increased domestic food production and changes in patterns of consumption in order to reduce a growing dependency on imports (from the current thirty-three million tonnes per year to fifty million by 2030) and overseas land demand (UK NEA, 2011). Urban



area demands are disproportionate to their area land cover and responsible for the majority of such consumption. However, as centres of innovation (Dvir and Pasher, 2004), policy and leadership, they provide a valuable social-ecological resource and perspective in the promotion and execution of sustainable, joined-up resource management (Folke et al., 2011).

Such management approaches, if they are to be practical, resilient and sustainable need to acknowledge equally the social and ecological aspects of city living. From the ecological perspective, novel approaches to effective, provisioning urban environments have been put forward such as the concept of continuous productive urban landscapes (CPULs). The premise of CPULs is one where urban planning and architectural design seek the integration of a connected network of ecologically and economically productive outdoor spaces (Holdsworth, 2005). The hallmark of such productivity from a CPULS perspective is an emphasis on urban agriculture which the authors of the model view as essential green infrastructure (Viljoen et al., 2005). A major inspiration for this and other examples of the promotion of informal, improvised urban agriculture is the successful response to the country's oil crisis demonstrated by community agricultural programs ("organoponicos") in Cuba during the 1990s (Viljoen and Bohn, 2012). The architectural underpinnings of CPULs present urban agriculture primarily as a productive physical design element in the green infrastructure of towns and cities, largely ignoring the social-ecological contexts and tensions of such novel urban land management. Ernstson (2013) explores the socially-mediated distribution of ecosystem services and others (e.g. Barthel et al., 2010; Cumming et al., 2012; Barthel et al., 2013) have put forward models of social-ecological networks and knowledge transmission through which UA-derived adaptive capacity is critically embedded. These latter studies however fail to quantify the production of ecosystem services on-the-ground or explore those practices which determine such provision.

The contribution of urban environmental movements has been illustrated as potentially critical as pockets of resilience in associated social-ecological systems (Barthel et al., 2010). In particular those practices relating to food production and the generational transmission of social-ecological knowledge have been asserted as foundational for the adaptive capacity of urban areas to food insecurity (Barthel et al., 2013). The same authors point out that such urban environmental responses are not new in themselves and that urban food movements, typified by allotment gardening, have a long history as social-ecological answers to

threatened levels of food security (see Barthel et al., 2011; Barthel and Isendhal, 2013; Barthel et al., 2013). However, the modern western approach to the management of ecosystems, at all scales, has become increasingly centralised, removed from the influence and input of local stakeholders and monopolised by sectorial, expert-led decision making (Biggs et al., 2010). Therefore, an adoption of the spirit and principles of such historical examples of local environmental stewardship is, in that sense, reformatory and a form of modern social-ecological innovation towards more decentralised, diversified, resilient forms of natural resource governance (Andersson et al., 2007).

The resurgence of a civic ecological approach to natural resource management and the benefits which may result has been explored conceptually through an appreciation of urban green space as “green commons” (Colding and Barthel, 2013) and through the management approaches observed at allotment gardens and other informal green spaces (Ernstson et al., 2008) as retainers of social-ecological memory – an important ingredient for urban resilience. The advantages of such informal, adaptive approaches to local ecosystem management have been acknowledged also by governments. The UK NEA asserted the social and ecological sustainability which should be made possible through the adoption of a “Local Stewardship” approach to environmental resource management. Such an approach would include “the creation of green areas with a focus on food production and recreation opportunities through allotments, permaculture gardens and urban farms” (UK NEA 2011, TR 25.4.2).

The importance of linking local social-ecological memory with higher levels of governance has been underlined as a necessary attribute in providing cross-scale food security and resilience in complex social-ecological systems (Le Vallee, 2007; Nelson and Stroink, 2014). Case studies which address local resource governance, food production and the wider production of ecosystem services in urban areas are few however. A better understanding of how such innovation occurs in the landscape and the efficacy of ecosystem service provision related to such social-ecological practice would add confirmation to some of the assumptions made about its contribution to social-ecological resilience.

## **2.13 Aims and objectives**

### **2.13.1 Theoretical perspectives**

Following the literature review and based on the historical background of the study area (see Chapter 1), it was posited that community-led management of green common spaces, particularly with an emphasis on food production, could provide benefits to urban residents by way of ecosystem services as a form of social-ecological innovation which fulfils the criteria in Section 2.12. Furthermore, such examples of local ecological innovation, co-emerging around individuals or groups of concerted socio-environmental actors across the urban landscape, could represent a significant cross-scale ingredient of adaptive management and social-ecological resilience (Sections 2.10 to 2.12). Such innovation, emerging from urban actor groups, has the potential to comprehensively address those tenets of environmental stewardship, explored earlier in this chapter (Section 2.1). The local production or enhancement of ecosystem services by urban social-ecological networks of community-led nature-based initiatives could represent a significant contribution to urban natural resource management (Sections 2.5 and 2.6). Such initiatives, as a form of organised social-ecological innovation (OSEI), address concurrently those principles and aims drawn from the ecosystems, resilience and sustainability management frameworks. As detailed earlier in this chapter, much has been asserted in the literature regarding the importance of the healthy production of ecosystem services for the future of urban areas (Sections 2.3 and 2.4). To this end, the need for a more polycentric form of resource governance has been identified (Section 2.6). The hallmark of such governance should be an emphasis on building adaptive capacity and response diversity in order to enable urban social-ecological systems to withstand internal and external fluctuations and ensure the continued production of vital ecosystem services into the future (Sections 2.1 and 2.6). Informal, civic approaches to management of urban green spaces has been increasingly posited as one of the social-ecological elements in the urban landscape which may contribute to such forms of adaptive governance (Sections 2.10 and 2.11). The majority of the research underpinning such assertions however, has adopted a conceptual, theoretical stance in its appreciation of the role of such approaches without offering a detailed, empirically based quantitative evaluation of the contribution of such elements to adaptive capacity and actual production of ecosystem services. A clearer understanding of the dynamics which influence the

emergence of such innovation in the landscape as well as the implications for short-term productivity and long-term resilience of ecosystem services is therefore timely, and is the main purpose of this thesis.

Upon completion of the literature review and based on existing knowledge of the study area, three key theoretical perspectives were clarified, as follows:

- I. Organised social-ecological innovation could contribute vital urban-relevant ecosystem services to local areas.
- II. Such forms of innovation are implicit in the social-ecological resilience of the urban landscape.
- III. Food production may be a principal ingredient of OSEI, significantly mediating its emergence and subsequent productivity.

In order to explore the validity and salience of the theoretical perspectives drawn out from previous sections in this chapter, a series of aims and objectives were drawn up which provided the basis for focussed research into these aspects of OSEI:

#### **2.13.2 Research aims**

1. To define the role of social-ecological innovation in relation to the interconnected management goals of ecosystem services, sustainability and social-ecological resilience as represented in Figures 2.6 and 2.7.
2. Evaluate the contribution of OSEI to adaptive governance in the urban social-ecological landscape.

#### **2.13.3 Objectives**

- i) Map the occurrence, distribution and social-ecological context of OSEI, at the landscape-scale, in the areas of Salford, Manchester, and Trafford. Specifically, evaluate socio-economic and ecological characteristics of OSEI localities as drivers of innovation which identify OSEI as a potentially adaptive response.
- ii) Identify common practices and evaluate the prominence of UA in social-ecological innovation towards a working typology of OSEI.
- iii) Example the impact of OSEIs in terms of provision of ecosystem services to the locality through an exploration of specific cases.

- iv) Investigate variability in OSEI design and management in order to highlight the implications thereof for ecosystem service provision and response diversity in the landscape.
- v) Evaluate the economic value added to ecosystem services by OSEI-related ecosystem services.
- vi) Measure trade-offs and synergies between ecosystem services and OSEI characteristics which contribute to ecosystem services.

The exploration of research objectives i) and ii) will involve an examination of OSEI at the landscape-scale to test whether the occurrence of OSEI is influenced by social and ecological conditions. As such, these conditions define the context of OSEIs and it is with specific reference to these local environmental conditions that the term *context* is largely used in this thesis. Likewise, terms such as *adaptive*, *adaptability* and *niche* describe OSEI distribution as revealed by a landscape-scale investigation of the distribution of the phenomenon according to a snapshot assessment of social-ecological conditions (although some historic data related to change in social deprivation over time is considered in the analysis in Section 4.2.4). Similarly, objectives iv) and vi) are completed through an in depth case study which takes a snapshot view of OSEI design and management and draws on quantitative data in the drawing of statistical conclusions. Objective v) is met through a combination of data from both landscape-scale and local-scale studies and uses proxy values in a valuation of OSEI in the study area (Section 6.1.1). A view of changes in OSEI management, design or distribution *over time* did not form part of the research aims of this thesis, which would require a much longer time-based study and the inclusion of a greater range of qualitative as well as quantitative methods. As such the analysis presented herein presents a *point in time* perspective of the phenomenon of social-ecological innovation.

## Chapter Three: Research Methodology

### 3.1 Theoretical framework

In order to address the aims and objectives outlined in the previous section, two theoretical frameworks were employed which drove the direction of the research. These were the resilience framework (incorporating the theoretical tools of systems thinking, adaptive cycles and panarchy) and principle 5 of the ecosystems approach (specifically, the production of ecosystem services). By employing these two heuristics it was possible to evaluate the presence of OSEI both in terms of the landscape scale contribution to adaptive capacity and the local scale production of ecosystem services. The two frameworks also invite conclusions on different spatial and temporal scales, whereby the long term continuation of the immediate benefits to residents by way of ecosystem services is determined by the level of resilience inherent in their production (Biggs et al., 2010).

When speaking of resilience it is important to qualify the concept by defining both its content and context. In other words, specifying the resilience of *what* to *what?* (Carpenter et al., 2001; Liu, 2014). Furthermore, a valid approach to theorising and quantifying the term necessarily involves the application of a systems approach to thinking about those interconnected elements which contribute to resilience. The urban environment, as a markedly complex social-ecological system, provides the milieu of this research and, in broad terms, the resilient production of ecosystem services in the urban landscape is the subject of this thesis. Accordingly, *resilience*, as it appears herein, implies the level of adaptive capacity to those internal and external fluctuations which may compromise existing levels of ecosystem service provision. A holistic, systems approach to thinking about resilience requires an appreciation of multiple-scale processes and levels of connectedness within a given system (Naveh, 2000; 2005). This is permitted in the current research through a cross-scale examination of OSEI encompassing spatial, social-ecological and temporal perspectives and which employs both holistic and reductionist methods of analysis. At the larger scale, OSEI is explored as a coherent, functional element in the wider landscape and is studied in the context of surrounding social-ecological conditions (see Sections 4.1.1 to 4.1.5 for details of data collection and analytical methods). At the micro-scale, the potential of OSEI as a valid contributory element towards adaptive capacity is informed by an empirical

assessment of the dynamics of on-the-ground ecosystem service provision. The use of the two overarching frameworks and subsequent analytical approaches adopted in this thesis have thus been tailored specifically to inform an appreciation of ecosystem service provision in adaptive urban social-ecological systems and are summarised accordingly in Table 3.1

**Table 3.1 Theoretical frameworks adopted in this thesis.**

<b>Theoretical framework</b>	<b>Analytical approach</b>	<b>Spatial Scale</b>	<b>Temporal Scale</b>
Resilience	Holistic (systems thinking)	Landscape	Long-term
Ecosystem Services	Reductionist	Local	Short-term/immediate

### **3.2 Research overview**

The epistemological foundation upon which this thesis rested drew on multiple research strategies under an overarching embedded case study methodology which was primarily inductive by nature. The work followed a three-step sequential process which involved an initial exploratory approach to the subject consisting of a mapping exercise of OSEI in the study area followed by an embedded case-study and subsequent synthesis which combined data from the previous two steps, drawing analytical and statistical conclusions. Specifically, the mapping exercise presented in Chapter 4 adopted an exploratory style to an investigation of the study area for evidence of organised social-ecological innovation. Although exploratory in nature, the mapping exercise was underpinned by certain theoretical perspectives, derived from the review of literature in the previous chapter of this thesis, which informed the data collection process (see Sections 2.12 and 4.0). The approach to mapping examples of OSEI was necessarily exploratory given that evidence of innovation of social-ecological nature in the study area was only anecdotal and historical. The direction of the research therefore depended on the results of this initial exercise which laid the foundations of subsequent methodology choices. In terms of the occurrence of OSEI, initial *exploratory* observations regarding their distribution informed further *explanatory* methods of analysis aimed at detailing the conditions which were likely to produce OSEIs in the study area.

Data for this stage in the research were collected using a snowball sampling approach after Goodman (1961) combined with open source archival data from the Office for National Statistics, Department of Communities and Local Government, UK Census, Experian, and the United States Geological Survey. Analysis of the data in this chapter adopted a quantitative explanatory approach in order to evaluate the influences and contexts of OSEI as a social-ecologically mediated phenomenon (Sections 4.2.1 to 4.2.7). Specifically the social-ecological context of instances and types of OSEI was the focus of the analysis rather than a functional appreciation of OSEI as a practice. This allowed the analysis in Chapter Four of the research to effectively address objectives one and two as defined in Section 2.13.3.

The exploratory study in Chapter 4, which detailed the circumstances and provided a working typology of OSEI in the study area, provided the basis for a more detailed analysis of OSEIs through an embedded case study design. This allowed for an in-depth investigation of in-situ examples of OSEI to detail the phenomenon in its real-life context (Chapter 5). The research thereby follows the example of other related work employing the case study approach as a means to understand social-ecological forms of resilience (e.g. Folke et al., 2002; Olsson et al., 2006; Walker et al., 2006; Ernstson et al., 2010) and urban ecosystems services (Tratalos et al., 2007; Ernstson et al., 2010; Niemelä et al., 2010). Chapter 5 develops the initial mapping study by adopting a descriptive research approach to evaluate the site-specific qualities evidenced by OSEI through the lens of the ecosystem services framework (MEA, 2005). Data for this stage in the research were acquired through site surveys, consultations and direct observations. Consultations involved gathering numerical data on volunteer hours and details of the frequency of educational events from group facilitators and/or managers at OSEI sites. This took place either via correspondence (e-mail or telephone conversations) or in person during the carrying out of site surveys. Where information/managers were not readily available at this time, further site visits were made to complete the data collection. Direct observations of a qualitative nature involved assessing site access and physical context (e.g. the use of secure fencing or visibility of sites from street-level). Further details and justification of data collection methods related to specific ecosystem service assessments are presented in Sections 5.2 to 5.2.5.

As such, although empirical data collected during the case study was primarily quantitative by nature (see Sections 5.2.1 to 5.2.5), qualitative information was also acquired during the data collection process. Such information covered aspects of site security, access/opening



hours and geographic context. Accordingly, following the mixed-methods case study approach, the data analysis in this chapter combined descriptive and correlational approaches. This allowed a critical evaluation of the typology established in Chapter 4 by examining actual cases and comparing commonalities and differences in design and productivity between sites according to type. Detailed site surveys also provided a means to explore the effect of OSEI context and design on ecosystem service production. Further statistical analysis of trade-offs and synergies in ecosystem services (Chapter 6) permitted generalisations to be made about the phenomenon in the wider landscape (of which the case study represented 11%).

The integrated analysis of trade-offs, synergies and valuation of ecosystem services, presented in Chapter 6 of this thesis, followed an inductive style in order to identify relationships between OSEI site design, management and ecosystem service provision using correlational methods. The methodological approach to analysis of synergies and trade-offs between ecosystem services and site characteristics is presented in Sections 6.1.2 and 6.1.3. The latter follows an explanation and justification of an approach to monetary valuation of ecosystem services associated with OSEIs in Section 6.1.1. The methodology therefore integrates a range of methods of analysis covering a landscape-scale study of OSEI as an element in the socio-geo-physical system which made up the study area, as well as detailed evaluations of site design, along with an appraisal of values, synergies and trade-offs in ecosystem services. The former approach identifies the place of such innovation in complex systems as a potential adaptive response and as such stems from and further informs similar approaches to studying adaptive capacity (e.g. Folke et al., 2005). The descriptive analysis of design and ecosystem service production at case study sites in Chapter 5 offers an empirical assessment of services related to the social-ecological functions of OSEIs. This level of empiricism and detail has rarely been achieved in evaluations of urban gardens and green space (Pataki et al., 2011), much less with reference to discrete *types* of urban green space. A case study, investigating identified instances of novel, productive types of green space, thereby goes some way to address this gap. An analysis of synergies and trade-offs in urban ecosystem service production addresses a current research imperative, as explored in e.g. Haase et al. (2012) and Queiroz et al. (2015), but currently under researched at the micro-scale with reference to innovative green space management. A valuation of services, explained in Section 6.1.1 and presented in 6.2.1, employing established valuation methods

derived from relevant literature, completes a comprehensive evaluation of OSEI in the study area covering distribution, context, design, productivity and valuation. The methodology employed in this research therefore draws on current approaches to research into resilience and ecosystem service provision in social-ecological systems but provides a synthesis of methods, scales and analyses bringing a much needed level of detail and integration to the subject, hitherto previously neglected in the literature.

In summary, the research pursued a largely inductive style throughout but which, at specific points in the process, was also informed and developed by explanatory, descriptive and deductive stances. The methodology followed an established approach to knowledge acquisition whereby an initial exploratory investigation of the phenomenon of interest led to an explanatory approach to analysing its occurrence (Shields and Rangarjan, 2013). This in turn informed the selection of cases, variables and data collection methods towards an in-depth descriptive approach through a detailed case-study. The data thereby acquired allowed for a reductionist approach to be subsequently employed, using statistical methods to make confident generalisations on the chosen subject. As such the research followed an *explore-explain* sequence at the landscape-scale succeeded by a *describe-explain* sequence at the micro-scale in the pursuit of the aims and objectives set out in Section 2.13.

Specifically, the adoption of the social-ecological system paradigm (Berkes and Folke, 1998; 2003), allowed for the incorporating of the related heuristics of resilience thinking (Gunderson and Holling, 2002; Walker et al., 2002) and the ecosystem services framework (MEA, 2005) into an evaluation of the contribution of OSEI to the resilience of urban ecosystem services.

Given that the occurrence, distribution and productivity of OSEIs were the primary sources of data for the contribution of OSEI to adaptive capacity for ecosystem services, a quantitative approach allowed for both greater breadth and accuracy in the analysis.

Research into the resilience of social-ecological systems has employed qualitative methods such as those which attempt to understand the role of stakeholder participation in adaptive natural resource governance (Walker et al., 2002) as well as into perceptions and motives in the occurrence of civic ecological movements (Schultz et al., 2007). Such work is anchored largely in theoretical discussion and has provided insight into institutional and organisational dynamics (Olsson et al., 2004). However, there is as yet little empirical quantitative study into the geographical distribution, drivers and productivity associated with innovative

stakeholder-led ecosystem management. Case studies employing qualitative approaches have tended to focus on single or limited numbers of cases (e.g. Berkes and Folke, 1998; Folke et al., 2002; Adger et al., 2005; Halliday and Glaser, 2011) and, as such, have not provide convincing conclusions about the spatial characteristics of stakeholder-led ecosystem management at the landscape-scale such as those occurring within cities. Understanding of the latter would inform an evaluation of the contribution of decentralised approaches to urban ecosystem management. Such an analysis can only be accurately described through quantitative spatial data at the larger landscape or regional scales. Data on the social-ecological attributes within the landscape (in this case Manchester, Salford and Trafford), thereby provide a context to explore social-ecologically mediated patterns of distribution. More qualitative methods do not allow for a statistical approach to analysing trade-offs and synergies between locally generated urban ecosystem services, nor allow for a reliable approach to looking at patterns of productivity. Such an approach to productivity requires the drawing of conclusions from statistical analyses from a reductionist viewpoint. Where quantitative approaches to analysis of productivity and trade-offs between ecosystem services have been applied, research has often take a landscape view (Bennet et al., 2009; Daly et al., 2009; Nelson et al., 2009; Power, 2010) which does not acknowledge the importance of innovative management of multi-functional green spaces at the local-scale, thereby lacking critical detail.

That said, some of the discussion, in Chapter 5 particularly, is drawn from data derived from *qualitative* observations. Specifically, information on site access, visibility and physical setting was gathered from direct observations and informed a descriptive evaluation of such factors (Sections 5.2.5, 5.3.1, 5.4.6 and 5.4.7). Qualitative data on site access provided categorical data which enabled a statistical analysis of volunteer input. The methodology thereby combined and integrated qualitative and quantitative techniques to some degree. However, given that the exploration, description and explanation of relationships involved in the occurrence and productivity of OSEI, across scales, a general quantitative approach best facilitated the analysis. A more qualitative methodology may have created pathways to understanding participant motives and perspectives as well as group structure and management styles associated with OSEI. However, such data were not key to the remit of this thesis which was primarily concerned with identifying spatial patterns and

characteristics based on ideas of system resilience at the landscape-scale and site productivity at the micro-scale.

### **3.3 Justification of the case study approach**

As an innovative, semi-formal social-ecological phenomenon in an urban setting, OSEI presented itself as being a potentially highly complex subject of research. As such, OSEI lent itself to the usage of diverse methodologies (as detailed in the previous section). One powerful method for encompassing such a diverse approach to planning research into inherently complex systems is through a case study framework (as seen in Folke et al., 2005; Anderies et al., 2006; Walker et al., 2007). Furthermore, given that the research addressed multiple social-ecological scales, an embedded case study paradigm allowed for a sequential, dual-scale acquisition of quantitative data and subsequent synthesis of the two. This approach provided scope for an exploration of the “situation” regarding OSEI in the study area through historical data, open source data and through the gathering of real-time evidence of OSEIs. Through this exploratory process the establishment of a typology of OSEI was facilitated as well as the identification of prominent associated ecosystem services which then allowed for a detailed descriptive investigation of the specific characteristics of OSEI as an embodied social-ecological practice.

Adopting a case-study approach, it was possible to select well-established sites of social-ecological innovation which enabled an in-depth appreciation of “on-the-ground” site management and associated service production in a “real-life context” (Yin, 2003) rather than extrapolating solely from derived data (Bromley, 1986), as often seen in landscape-scale analysis of ecosystem service provision (e.g. Tschardt et al., 2005; Nelson et al., 2009; de Groot et al., 2010; Liu et al., 2010; Lavorel et al., 2009). Furthermore, OSEI is, by nature, an innovative and context-specific phenomenon which, thus far, has been relatively under-researched. It presents, therefore, a unique presence in the urban environment which, although widespread, is, as yet negligible in terms of land cover compared to other kinds of urban green space. As such, OSEI can be seen as a special-case of urban green space cover, warranting an in-depth approach to documenting the mediums by which it takes expression in the landscape (Leedy and Ormrod, 2001).

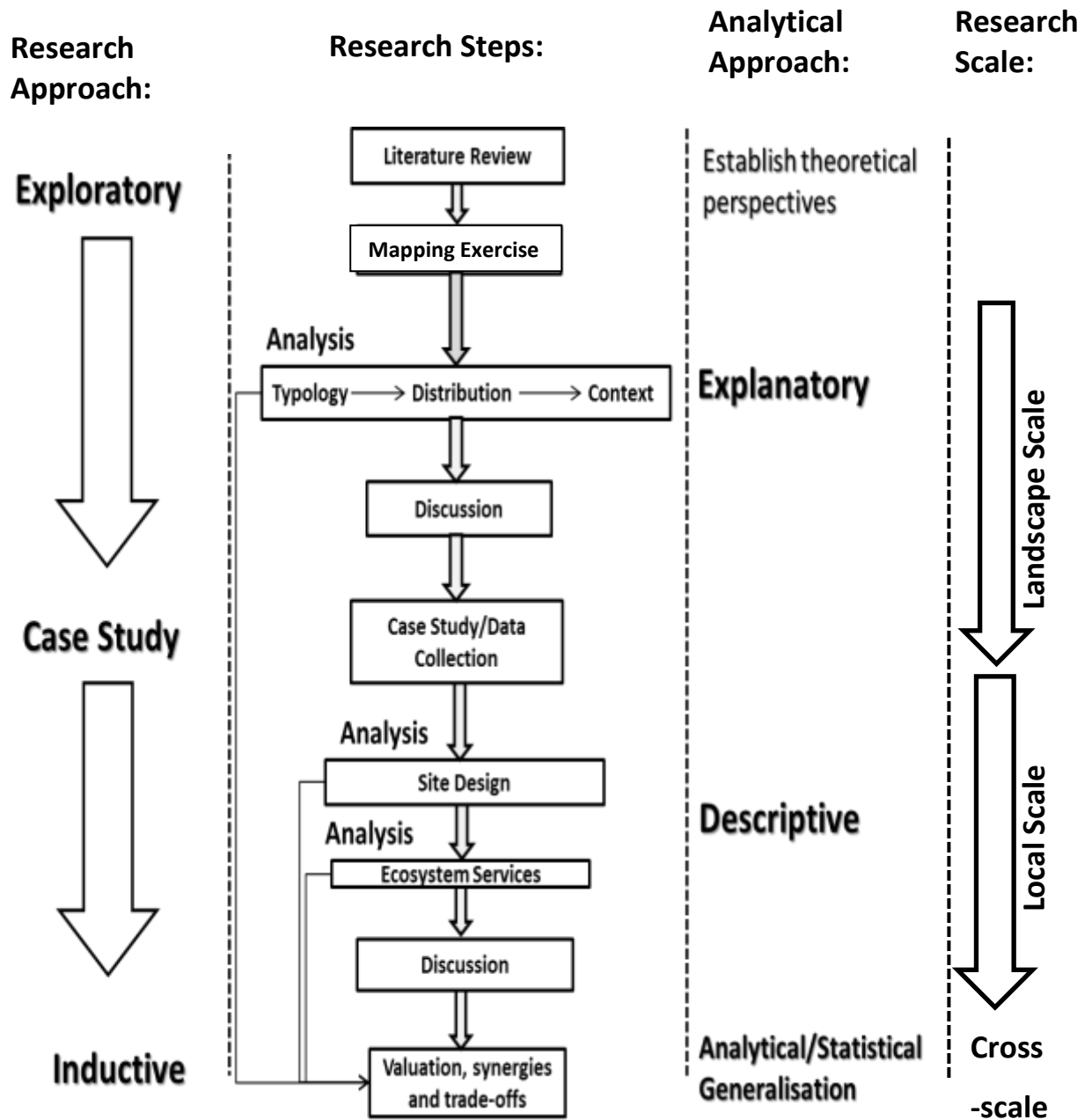
In order to evaluate the ecosystem services most closely associated with OSEI and, in order to arrive at the most suitable and effective data collection methods to quantify those

services, a case-study approach was necessarily involved. Given the innovative nature of site management and design, the selection of sites, of data collection methods and of ecosystem services most commonly produced at OSEIs, was an organic, iterative process whereby methods and materials were developed in an ongoing process informed by a series of preliminary site visits. As such, a case-study approach served to confirm, and provide the opportunity to re-define, terms and cases as further details were gathered in the initial data collection. Such an approach is regarded as essential when research is focussed on an inductive approach to in-depth investigation of real-life cases (Yin, 2003). This process also helped to validate the typology of OSEI determined in the mapping exercise in Chapter 4. The exploratory nature of the research, avoiding narrowly defined hypotheses which may have precluded otherwise pertinent revelatory observation in this little-documented phenomenon, also lent itself to a case-study investigation of examples of OSEI.

The integrated analysis covering valuation, synergies and trade-offs presented in Chapter 6 of this thesis, brings together elements of the mapping study and the case study to make analytical and statistical generalisations about the phenomenon under investigation. As such, this concluding phase of the research continues in a case study style, drawing on a range of analytical and statistical methods whilst following the overarching inductive approach to knowledge which underpinned the work as a whole.

The process and design of the research overall resembled closely that of a case study approach containing multiple embedded layers of physical and conceptual elements. From a landscape scale perspective, an investigation of the physical OSEI distribution was conducted and analysis of the extent to which the phenomenon was embedded in, and mediated by, social-ecological and historical contexts. The latter was explored by recording the frequency of OSEIs which occurred within the vicinity of historically important centres for social-ecological innovation during the 20 year period leading up to the present study, as documented in Section 1.2. Similarly, at the micro-scale, ecosystem service production was explored from a socio-spatial perspective covering OSEI site design and management. Conceptually, the research was conducted through a sequence of nested epistemological stances which were employed individually at discrete stages in the research process. This flexible approach to the study allowed for a realistic appreciation of social-ecological innovation as a complex, dynamic feature of the urban landscape which is itself embedded

in the unique social and environmental configurations of a wider social-ecological system. An overview of this procedure is presented in Figure 3.1.



**Figure 3.1 Research Overview**

The mapping exercise, case study and subsequent analysis of synergies and trade-offs in ecosystem services are detailed sequentially in Chapters 4, 5 and 6, respectively. Specifically, Chapter 4 contains details of the socio-geographic contexts which drove and shaped the emergence of OSEI and established the social-ecological parameters of its occurrence. As such, the research in this chapter presents OSEI as a coherent phenomenon and maps

individual cases, providing a “population” of OSEIs for statistical analysis. In Chapter 5, a case study of 12 OSEIs, representing 11% of the total population, is described which evaluates elements relating site design, location and management. The associated production of four key ecosystem services is subsequently quantified. The final step in the research process is presented in Chapter 6. Here, the relative contributions of sites and types of OSEI in the case study are examined in order to understand how ecosystem services relate in terms of synergies and trade-offs, and how elements of site management contribute to service provision. In this way, Chapters 4, 5 and 6 explore, respectively, the “where”, “what” and “how” of OSEI in terms of distribution, design and productivity. The final chapter (Chapter 7) of the thesis provides an analytical synthesis of the findings from these three research perspectives. The relationship between these four phases in the research is summarised in Figure 3.2.

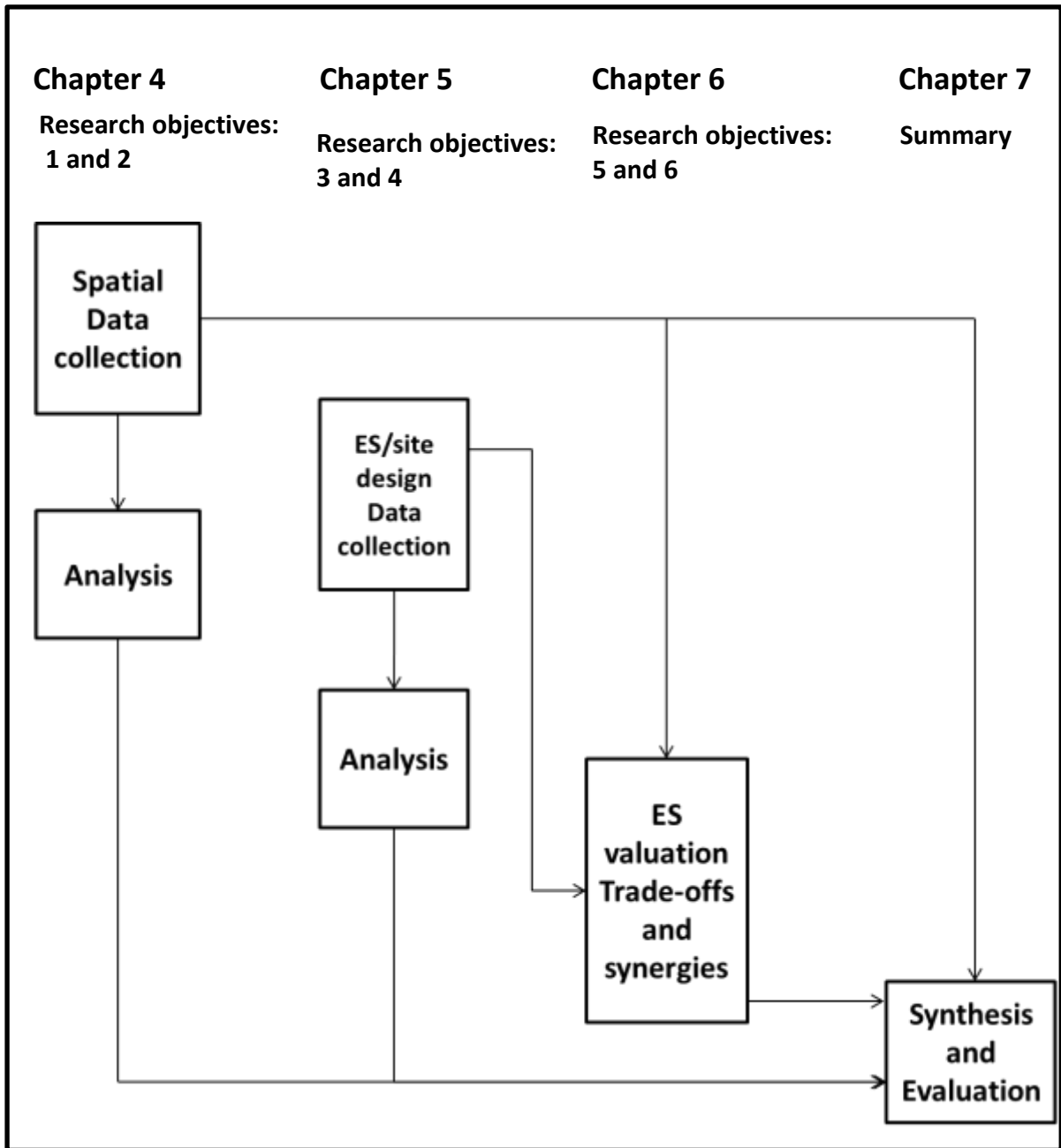


Figure 3.2 Relationship between research elements in this thesis.



## Chapter Four: Mapping Organised Social-ecological Innovation

### 4.0 Introduction

In Chapter 2 a critical review of the current canon of research into the dynamics of social-ecological systems, characteristics of urban ecology and the emergence of informal land use in cities was provided. Following the perspectives gained from this review and given the historical social-ecological context which provided the background to this thesis, as detailed in Chapter 1, a mapping study was carried out across the defined study area for evidence of innovative social-ecological activities. The initial study was carried out into the presence and distribution of community-led ecological projects across the areas of Manchester, Salford and Trafford. The exploration of examples of OSEI in the study area was informed by the inferences made following the literature review in the previous chapter (see Section 2.13). Based on these derived theoretical perspectives, the purpose of the exercise was primarily to address research objectives one and two (Section 2.13.3). In order to fulfil these objectives, the goal of the investigation, which drove the data collection process, was threefold:

- a) To map the occurrence of sites of organised social-ecological innovation (OSEIs), recording the extent and variety of such activity in the landscape.
- b) To investigate the prominence of urban agriculture as a medium for social ecological innovation, where sites were categorised according to whether or not food cultivation featured as a management outcome.
- c) To evaluate the physical/ecological, demographic and social-economic parameters of its occurrence.

### 4.1 Methods

Over a period spanning from July 2012 to July 2014, information on existing social-ecological projects in the defined study area were gathered using a snowball sampling approach to data collection (Goodman 1961) which began with the use of internet sources as a means to identify sites of OSEI and subsequent consultations with prominent actor groups. The sites

selected for study as pockets of social-ecological innovation had to meet at least one of the Olsson and Galaz criteria outlined in Section 2.12.

Initially information was gathered from Google searches using combinations of the search terms “community”, “garden”, “allotment”, “sustainable”, “projects” and location words “Manchester”, “Trafford” and “Salford”. Other websites for known local sustainability and environmental groups were visited periodically during the course of the data collection phase. These were AMAS (Association of Manchester Allotments Societies), FCFCG (The Federation of City Farms and Community Gardens), Feeding Manchester and the Environmental Network for Manchester. Existing reports on the status of community gardening and urban agriculture funded by local authorities were likewise consulted (Kazmierczak et al., 2013). Other prominent groups involved in social-ecological activities in the area were consulted directly, namely: The Kindling Trust, MERCi (Manchester Environmental Resource Centre initiative), Action for Sustainable Living, Hulme Community Garden Centre, Salford Council, Red Rose Forest, Start in Salford, City Camp Manchester and the Angel Centre, Salford. Groups were contacted in the first instance based on the author’s existing knowledge and social network and the snowball sampling approach continued until no more new projects were discovered. As sites were recorded they were assigned to two categories, namely those where urban agriculture was a feature of the site and those where it was not. A typology was subsequently created based on the management emphasis of each site. The spatial data on sites were initially plotted using Google Earth 7 and when the mapping exercise came to completion the site location data were entered into ArcGIS.9 software.

After the snowballing sampling process was complete, a total of 113 sites of organised social-ecological innovation had been identified. Using postcode look-up tables downloaded from the Ordnance Survey Open Data archive (Ordnance Survey, 2012), each site documented in the snowballing data collection process described above was converted to national grid coordinates and mapped against socio-economic and environmental datasets obtained from the Office for National Statistics (ONS, 2001; 2005; 2011), National Aeronautics and Space Administration (NASA, 2013), Department for Communities and Local Government (DCLG, 2010) and Experian (2009) sources. In order to address directly both the social, and ecological, aspects of the innovation being investigated, the demographic, socio-economic and physical contexts of OSEI locations (defined as the lower super output area in

which they occurred) were explored. This was achieved by obtaining administrative boundary datasets for the study area, in the form of census-derived lower super output areas (LSOAs), obtained from the EDINA Digimap online service (ONS, 2001; 2011). Demographic characteristics were explored using population and ethnic group datasets from the 2011 UK census (ONS, 2011.) Land cover variables were analysed using the ONS generalised land-use database (ONS, 2005) and normalised difference vegetation index (NDVI) modelled from Landsat imagery (NASA, 2013). Socio-economic features of the landscape area were investigated using Experian MOSAIC data downloaded from the UK Data Service (Experian, 2009) and by mapping Index of Multiple Deprivation data (DCLG, 2010) downloaded from the Department of Communities and Local Government website. All the above datasets were entered into ArcGIS.9 and analyses were carried out on the distribution and social-ecological contexts of the recorded sites as detailed in the following Section 4.2.

#### **4.1.1 Spatial distribution of OSEIs**

Sites were plotted against the boundaries of the three districts in the study area and their distribution was explored. Nearest neighbour analysis was employed to investigate whether the location of sites followed a clustered, uniform or random pattern of distribution. The ArcGIS intersect tool was used to determine which metropolitan boundaries sites fell into and proximity tools allowed for analysis of site distribution within an urban “catchment” area of 5km from the central city district. This radial distance was chosen based on those used define inner-city areas in comparable studies into urban environmental issues (e.g., Wilson et al., 2013). All spatial analysis tools were accessed through the ArcGIS.9 toolbox.

#### **4.1.2 Analysis of demographic characteristics**

The demographic characteristics of the locations of OSEIs were acquired through census lower super output area boundary datasets and using population statistics from the UK census data service (ONS, 2011). The study area was separated in to LSOAs where OSEIs were recorded and those where they were not. This was achieved through use of the ArcGIS.9 tools *join*, *spatial join* and *select by location*. The resulting attribute tables were

then entered into IBM SPSS.20 statistical package. Groups were then analysed for differences in ethnic group populations using Chi square and logistic regression statistical analysis. This allowed for a detailed evaluation of the unique demographic qualities of areas containing OSEIs. These two groups of LSOAs were likewise analysed across geo-physical and socio-economic characteristics as explained in the following sections.

OSEI locations were explored for usual resident population and for population by ethnic group as defined in the 2011 census terminology and a comparison of means (Mann-Whitney U-test) was carried out between OSEI locations (Group 1) and the remainder of the study area (Group 0).

#### **4.1.3 Analysis of physical (land-cover) characteristics**

In order to evaluate elements of the physical environment within the study area in which OSEIs occurred, sites were charted based on the Ordnance Survey-derived Generalised Land Use Database (GLUD) as employed by the Office for National Statistics. The rationale for this was that OSEI, in order to be considered as an adaptive response, and, thereby an element contribution to system resilience, ought to be sensitive to surrounding environmental conditions. The physical context of OSEIs, specifically types of green space and surface sealing, was therefore used to explore possible associations between land-cover types and OSEI occurrence. For the remainder of this thesis, the term *land-cover* will be used rather than the term *land-use* in order to avoid confusion over the type of surface cover (such as “green space”, “roads”) as denoted by the former, and the more purpose-oriented area descriptions, such as “recreational ground”, “golf course”, “parkland”, as denoted by the latter. In this respect the GLUD data describes, more closely, areas of land-cover as opposed to land-use. Furthermore, the discussion in this and subsequent chapters of the thesis will make specific reference to the use, purpose and multi-functionality of OSEIs and for which it is equally necessary to make a clear distinction between these two terms. These data on urban land-cover from the Office for National Statistics are available for individual lower super output areas, consisting of a range of principle land-cover categories and are provided in units of 1000m<sup>2</sup> per LSOA.

At this point it should be stated that Lower Super Output Areas are geographical units used by the Office for National Statistics to monitor changes in demographic data at the smallest scales. They are classified according to population, number of households and socio-

economic characteristics (ONS, 2012). As such, LSOAs are standardised by population rather than area and the geographic extent of LSOAs within the same administrative area can vary greatly. For the study area in this report LSOA size varied significantly as described in Table 4.1.

**Table 4.1 Study area LSOA basic statistics (2001 - 2010 boundary data, ONS).**

<b>Total number of LSOAs:</b>	541
<b>Area (1000m<sup>2</sup>)</b>	
<b>Minimum:</b>	103
<b>Maximum:</b>	18035
<b>Sum:</b>	317815
<b>Mean:</b>	588
<b>Standard Deviation:</b>	1137

A standard deviation of 1,137,000m<sup>2</sup> demonstrates the high variability in area between LSOAs in the study area. Area values for LSOAs containing OSEIs relative to those without did not vary to a significant degree ( $p = 0.124$ , Mann-Whitney U-test), with comparable means of 584,000m<sup>2</sup>  $\pm$  795,000m<sup>2</sup> and 589,000m<sup>2</sup>  $\pm$  1,186,062m<sup>2</sup>. However, given the large standard deviation (almost double the mean) of the GLUD data and, in order to achieve a standardised approach to land-cover analysis of OSEI locations, data were transformed into figures of cover density as m<sup>2</sup> 1000m<sup>-2</sup> in order to account for the large discrepancies in LSOA size.

The physical environment was initially explored using remotely sensed data to create a normalised difference vegetation index as an established method for monitoring vegetative extents in landscapes in which social-ecological systems are embedded (Zurlini et al., 2012). An appraisal of the distribution of OSEIs according to vegetative index as revealed by the NDVI modelling informed the subsequent analyses of the physical environment, through the GLUD, with regard to the distribution of the phenomenon.

Remotely sensed Landsat data (bands 3 and 4) were downloaded (NASA, July 2013) and, using ERDAS Imagine.10 software, the Normalised Difference Vegetation Index (NDVI) for the study area was calculated. Entering the resulting raster data into ArcGIS.9, the zonal

statistics tool was employed to give mean NDVI values for each of the Lower Super Output Areas used in the analysis. The NDVI data helped to visualise the vegetative character of the study area and also served as a standard as to the validity of the GLUD. However, the latter was used primarily in the analysis of the physical environment of OSEIs given that it provided more detail of land cover types and distinguished between, for example, public green space and domestic gardens, which allowed a greater degree of detail in the social-ecological analysis.

Characteristics of the physical environment of OSEI localities were compared with those of the rest of the study area where OSEI was not present (independent samples t-test and Mann-Whitney U-test in IBM SPSS.20) across several land-cover types. These were: green space, surface sealing, building cover and domestic gardens, all as a measure of density ( $\text{m}^2$   $1000\text{m}^{-2}$ ). This was done in order to determine the unique local conditions in the physical environment which influenced the emergence of OSEI in the study area landscape. Density values were calculated from the relevant GLUD dataset land-cover categories.

#### **4.1.4 Socio-economic analysis**

Site locations were also explored for socio-economic characteristics. Experian MOSAIC data (2009) was used to categorise areas (LSOAs) where OSEIs were present as defined by the most representative MOSAIC group per LSOA. As for the analysis of demographic and land-cover data, the study area was divided into two groups and analysis was performed using Chi Square test to determine if the two were statistically discrete (Section 4.2.2) based on this appraisal of local socio-economic conditions.

Further to this, Index of Multiple Deprivation (IMD) data were obtained (DCLG, 2010) to add detail to the socio-economic analysis of OSEI localities. These were explored against the IMD domains for Income, Employment, Education, Crime and Disorder and Health. Again locations of OSEIs (with lower super output area as the spatial context) were analysed through a comparison of means with that of the remainder of the study area. Accordingly, the spatial contexts of sites were established by examining the geographic, demographic, physical and socio-economic data available on the respective lower super output areas within which they occurred. In order to compare the relative effects of both social and ecological area characteristics on the distribution of OSEI in the study area, physical and

socio-economic parameters were consolidated into two single variables. The GLUD data were used to calculate the total extent of green space (public and domestic) per LSOA as a proportion of the total area, and overall IMD score was taken as general measure of socio-economic conditions in a given area. The relative effects of the two socially and ecologically derived variables on the occurrence of OSEIs were then compared. Mean differences between OSEI localities and the study area overall for both variables were compared (independent samples t-test and Mann-Whitney U test) and binary logistic analysis was carried out on the data to ascertain the relative impact of both social and ecological conditions on the emergence of OSEI in the study area. All statistical analyses were carried out using IBM SPSS.20.

#### **4.1.5 Analysis of the spatial distribution of types of OSEI**

Further spatial analysis was performed in order to assess the influence of area characteristics on the distribution of different types of OSEI which were recorded in the study area, employing the same datasets which were used in the initial analysis of OSEI distribution. OSEIs were separated into groups according to the typology which had been established during the snowball sampling process (see Section 4.2.1). A series of univariate analyses of variance was then carried out on the locations (LSOAs) in which these types of OSEI were recorded across physical (proportion of surface sealing), demographic (population density) and socio-economic (overall IMD score and individual domain indices) datasets in order to identify those social-ecological characteristics which best defined the contexts of particular approaches to OSEI.

The relative influence of physical and social parameters on the distribution and emergence of respective types of OSEI was confirmed by the carrying out of a discriminant function analysis of environmental, demographic and socio-economic factors (documented in Sections 4.2.2 to 4.2.4).

## **4.2 Mapping exercise: results**

The data analysis is presented first by the assigned categories into which OSEIs fell (Section 4.2.1), then by geographical distribution based on administrative boundaries and demographic data (Section 4.2.2). Land-cover data were included into the mapping study (Section 4.2.3) and further analysis was carried out with reference to socio-economic data (Section 4.2.4). These variables are consolidated in Section 4.2.5 and analyses of the spatial contexts of OSEI types are presented in Section 4.2.6.

### **4.2.1 Types of social-ecological Innovation**

The mapping exercise revealed that of the 113 sites recorded, food production was practised, taught or promoted at 90% of sites (see Appendix 1 for full listing). Based on the management and overall social-ecological remit of these sites, a typology was established which defined sites as belonging to one of five categories:

1. Community allotments
2. Community gardens
3. Community orchards
4. Pocket parks
5. Environmental resource projects

For the purposes of this research the above categories are defined as:

#### **1. Community gardens**

Although the two terms “allotment gardens” and “community gardens” are often used synonymously and interpreted liberally, for the purpose of this work “community garden” will be used distinctly to refer to areas of public green space which are maintained by members of the community for a range of activities and social provision, a proportion of which is often centred around gardening for food but with a range of additional structures facilities which serve priorities such as leisure and educational activities, social interaction, and provision of communal open spaces.



## **2. Community allotments**

These sites were pre-existing or adapted plots on established allotment gardens which had been designated by the local council as areas for use by the wider community primarily for food production and related educational activities. Of all types, community allotments and gardens were those which exhibited greatest similarity. However, in the majority of cases community allotments were identified as such either by signage or in other forms of publicity (e.g. internet presence). In cases where classification was not clear or self-designated, sites were allocated to the community allotment type where food production was judged to be the primary design feature.

## **3. Community orchards**

Community orchards within the thesis are defined as areas of land managed by local residents and volunteers which are dedicated primarily to the cultivation of hard and soft fruits. Features of site structure and management may overlap with those of the other three categories of social-ecological innovation as defined herein but the defining characteristic is the overarching emphasis of the production of fruit whether through traditional or modern techniques.

## **4. Pocket parks**

Pocket parks were those sites which, usually as a result of their location, exhibited the most highly improvised approach to urban greening. They are defined in this thesis as sites which occur in areas of high surface sealing and as such achieve their impact by maximising the use of available top soil and using an innovative array of container planting and other improvised naturalistic features such as green roofs and walls. This OSEI type was easily distinguishable from others in this list by the surrounding and pre-existing land-use. Sites occurred on pockets of land subject to high or complete surface sealing and, subsequently, were often much smaller than sites of other types. However, a minimum total area of 50m<sup>2</sup> was required, however, to be included in the analysis as below this size sites were not considered to be substantial enough to require considerable, clearly demonstrable levels of community input. On this basis some "sites" which were smaller than 50m<sup>2</sup>, and which generally consisted of large single or 2-3 small planted containers, were excluded. As well as being of a size below which could comfortably be considered a "site", such micro-features were often

part of a larger, multi-locational project such as Incredible Edible Salford (IES, 2015). As such, they were doubly problematic in that, even if considered as a single project, they could not be effectively mapped and considered as a single datum within the spatial analysis of individual sites. Such highly ephemeral, multi-locational examples of social-ecological innovation would require a treatment and evaluation separate from this study, which could be a topic for future research. Sites within the pocket park category, by virtue of their highly urbanised locations did not exhibit total areas greater than 250m<sup>2</sup>. Accordingly, of all types included in the study, pocket park, as the name suggests, were most easily defined by site area. Given the urban context of this spatially-oriented research (see also Section 5.2.6 and Sections 6.2.3 and 6.2.4), pocket parks were, from a purely spatial point of view, of particular interest. For this reason, the spatial dimensions of this type were clearly defined as being between 50m<sup>2</sup> and 250m<sup>2</sup>. Any site with a total area within this region was thereby classed as a pocket park.

## **5. Environmental resource projects**

The remaining sites formed a category of innovation which were not primarily land-based but which consisted of premises or mobile projects which served as hubs of environmental information, training or resources. Often such groups were actively involved in the promotion of social-ecological innovation and/or UA and in the forming of social networks between groups. Some of these sites also exhibited small-scale therapeutic or educational horticultural activities as a secondary service or as satellite projects. Some projects were, however purely “office-based” and, in some cases, multiple projects were housed in the same building.

In addition to the above categories of sites which had a physical presence in the landscape, there existed, as revealed in the data collection process, a number of actor groups which, although having no physical basis, were actively involved in the distribution of information, supporting and managing social-ecological networking activities as well as providing training and awareness-raising events. Examples include Envirolution, Transition Town, Feeding Manchester and City Camp Manchester. Being “dimensionless”, these actors in the landscape were not mapped, though their position in the social-ecological network is discussed in Section 4.4.5.

The first four types described herein represent horticultural approaches to OSEI and are primarily involved in land management and, in a majority of cases, food production. Accordingly, these types collectively consist of a *provisioning* approach to OSEI and are able to provide direct and indirect use benefits (as explored in Chapter 5). The latter two are principally devoted to providing resources, information, training and networking opportunities to groups and individuals involved in OSEI and related environmental activities. As such these constitute a *supporting* form of OSEI. These two descriptors are used distinctly from those which appear in ecosystem services categorisations (such as within the MEA, 2005) but perform a similar function. *Provisioning* in the context of OSEI describe sites which *provide* ecosystem services directly to their localities whereas *supporting* versions of OSEI exist to offer *support* to such provisioning sites. As sites were recorded and mapped they were placed into one of the above categories based on site characteristics. The results of this categorisation are presented in Table 4.2.

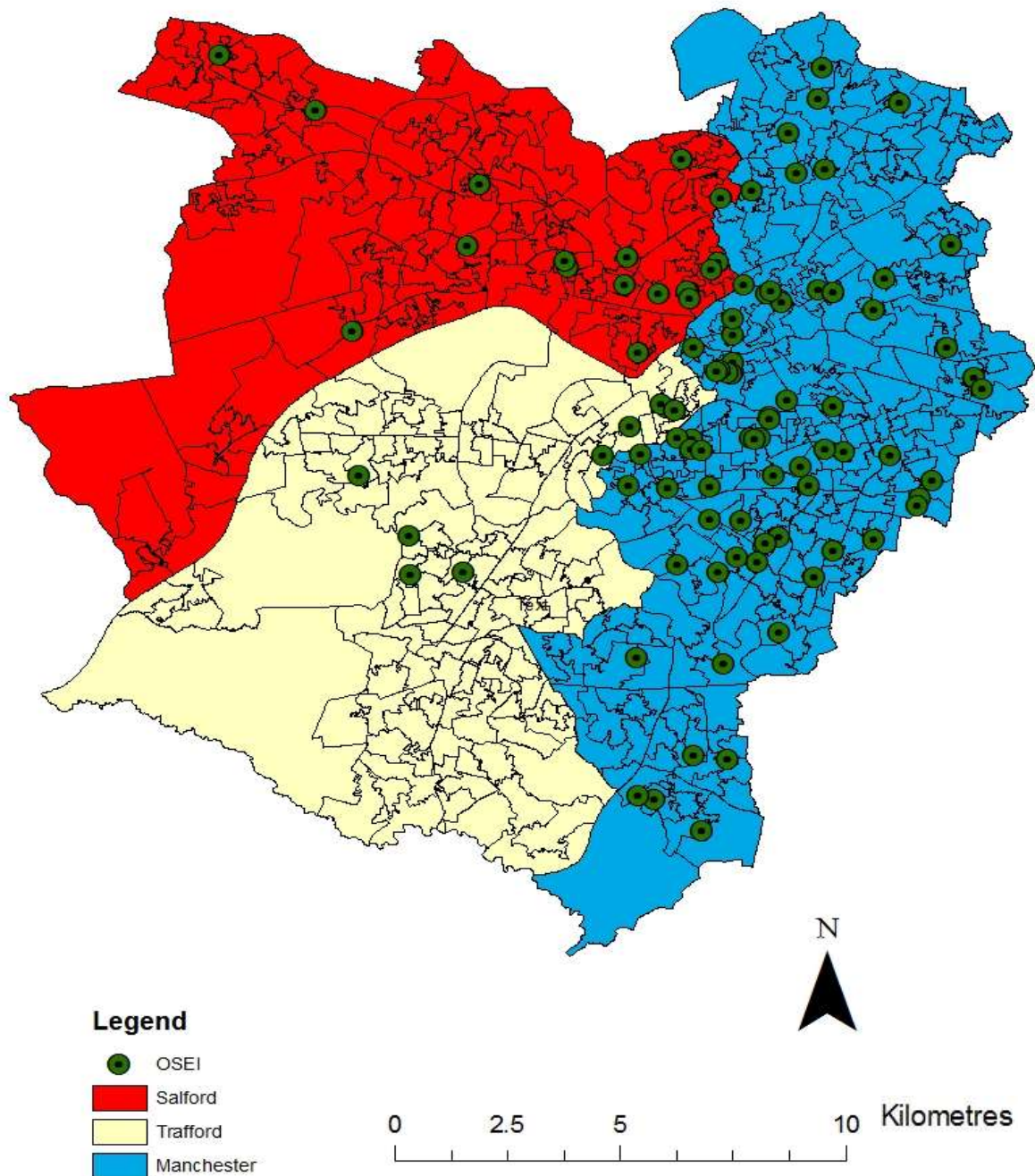
**Table 4.2 Site categories.**

<b>OSEI type</b>	<b>Frequency</b>	<b>Percent</b>
<b>Community garden</b>	40	35.4
<b>Community allotment</b>	23	20.4
<b>Pocket park</b>	15	13.3
<b>Community orchard</b>	13	11.5
<b>Environmental resource project</b>	22	19.5
<b>Total</b>	113	100.0

The most common form of social-ecological innovation appeared to be community gardens (35.4%), followed by community allotments and environmental resource projects, each accounting for around twenty percent of the total.

#### 4.2.2 Demographic analysis

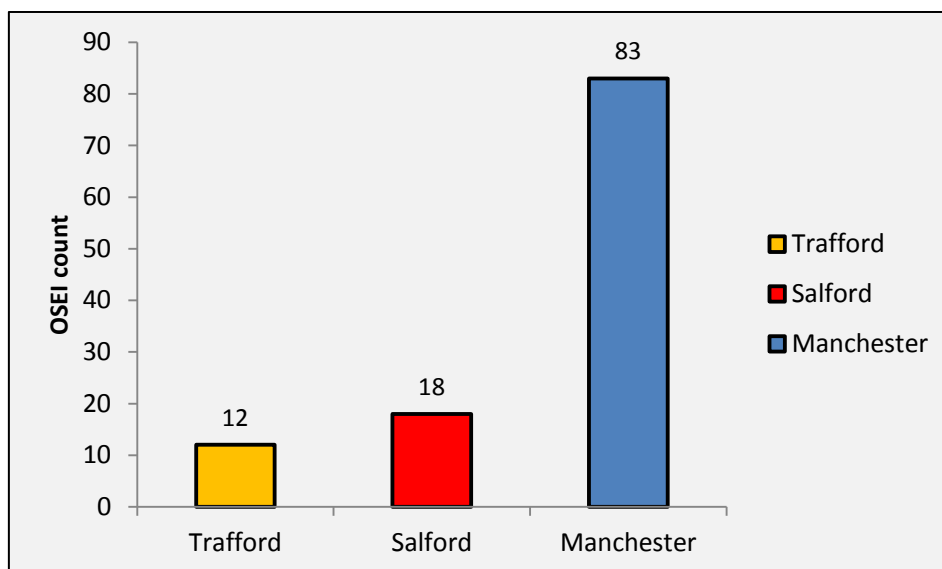
The spatial distribution of sites across the three administrative districts is described in Figure 4.1.



Internal boundary lines demarcate  
lower super output areas

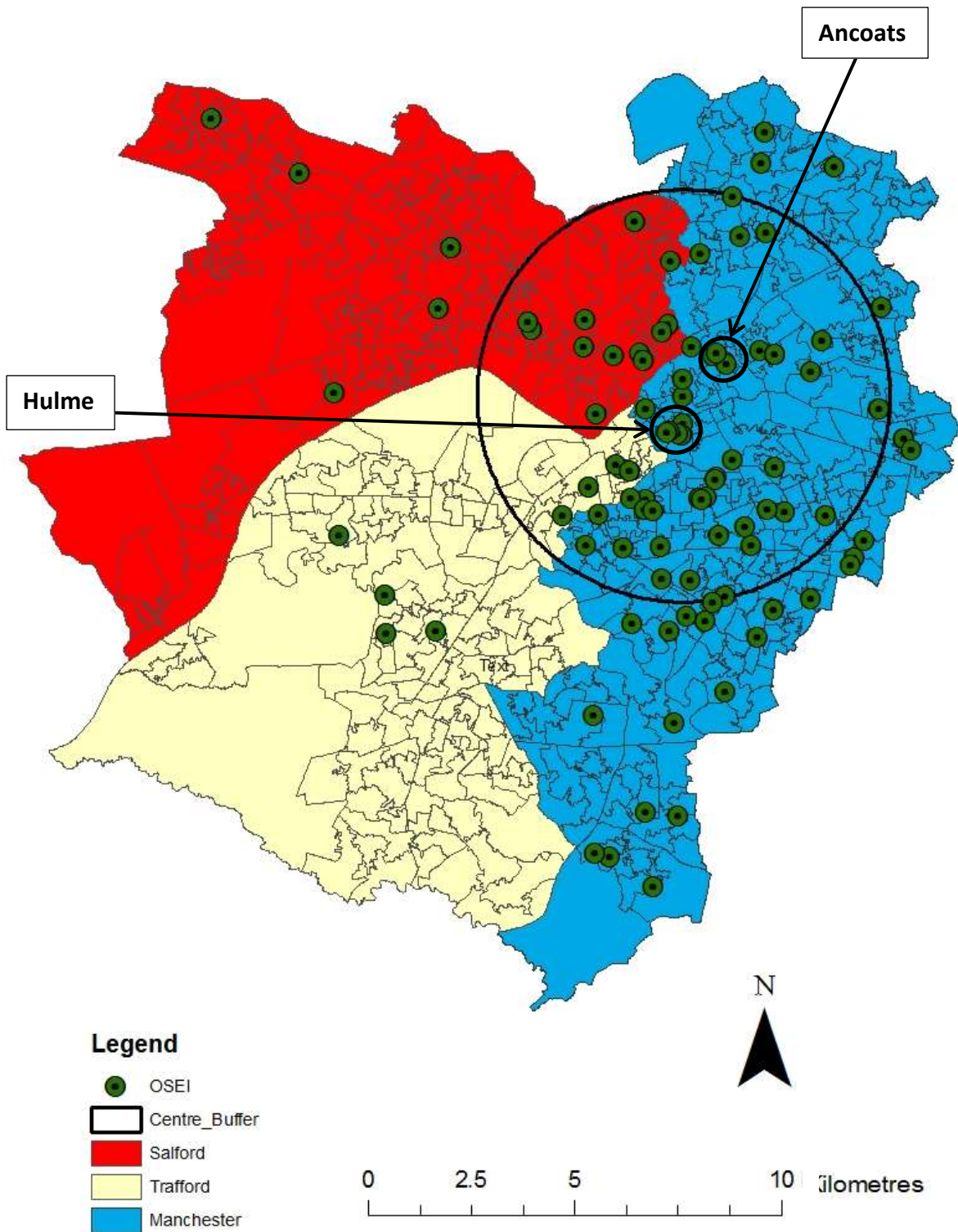
**Figure 4.1 Distribution of organised social-ecological innovation across the three districts in the study area (ONS, 2011).**

From the distribution in Figure 4.1, it would seem that the majority of sites fall within the boundaries of Manchester and that many sites are to be found clustered around the city centre of Manchester which serves all three districts. Figure 4.2 describes the distribution between the three areas.



**Figure 4.2 Site occurrence by district.**

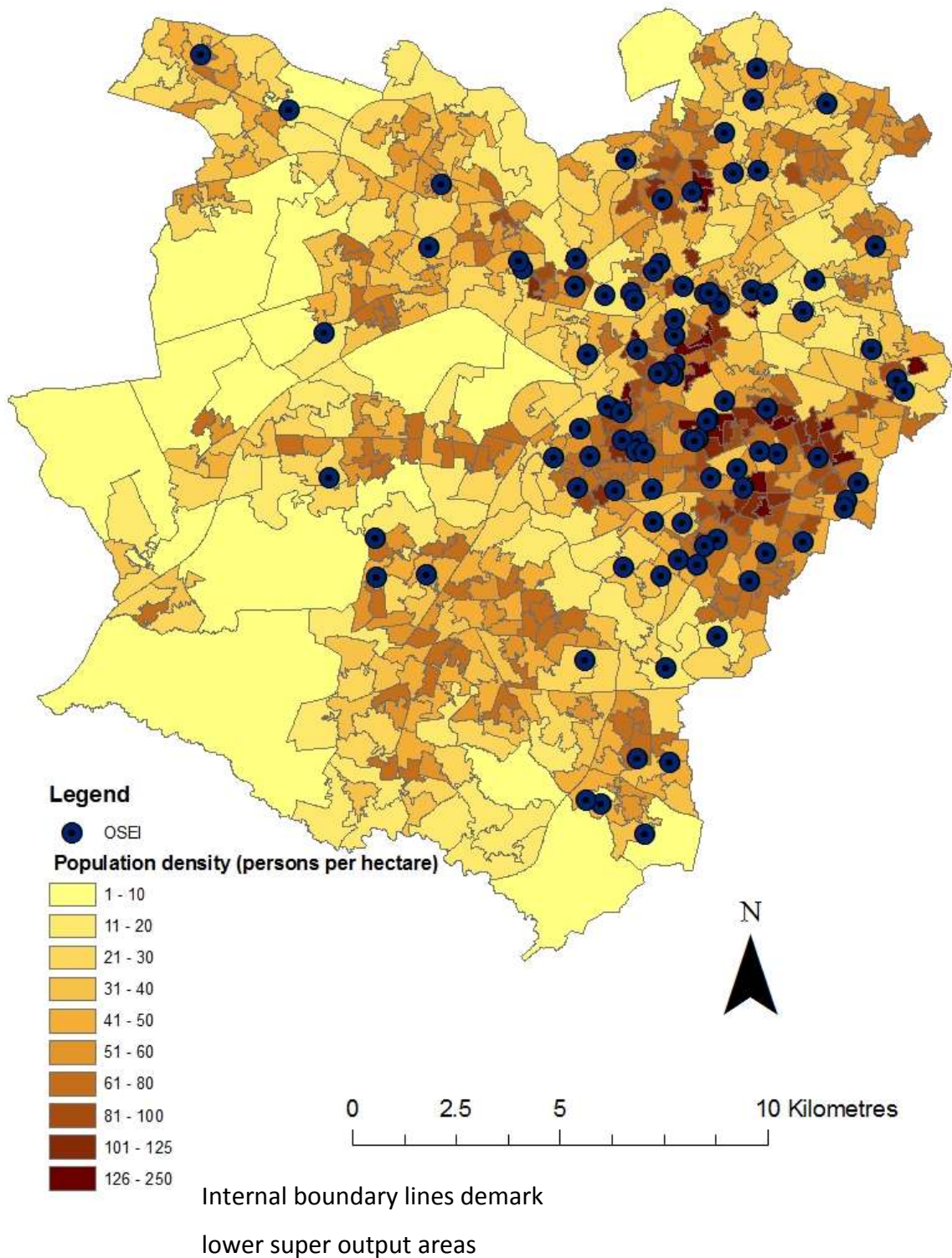
These data show that the majority of sites (73%) are to be found in Manchester with almost three quarters of sites falling within the boundaries of the city of Manchester. Salford contained the second highest number of sites with 16% of the total. Furthermore, two Manchester postcode districts M4 (Ancoats) and M15 (Hulme) appeared to contain a disproportionate number of OSEIs (21 collectively, equalling almost 20% of the population total, see Appendix 1). Upon initial observation of site distribution, there appeared to be a general clustering of sites around the Central Business District which comprises the city centre of Manchester. In ArcGIS.9, a proximity buffer of 5km radius was then created around Manchester City Centre to clarify this observation, as shown in Figure 4.3. Figure 4.4 highlights the populations around this inner-city area.



Internal boundary lines demark  
lower super output areas

Figure 4.3 OSEIs within 5km radius of Manchester city centre (ONS, 2011).





**Figure 4.4 Population distribution by lower super output area (ONS, 2011).**

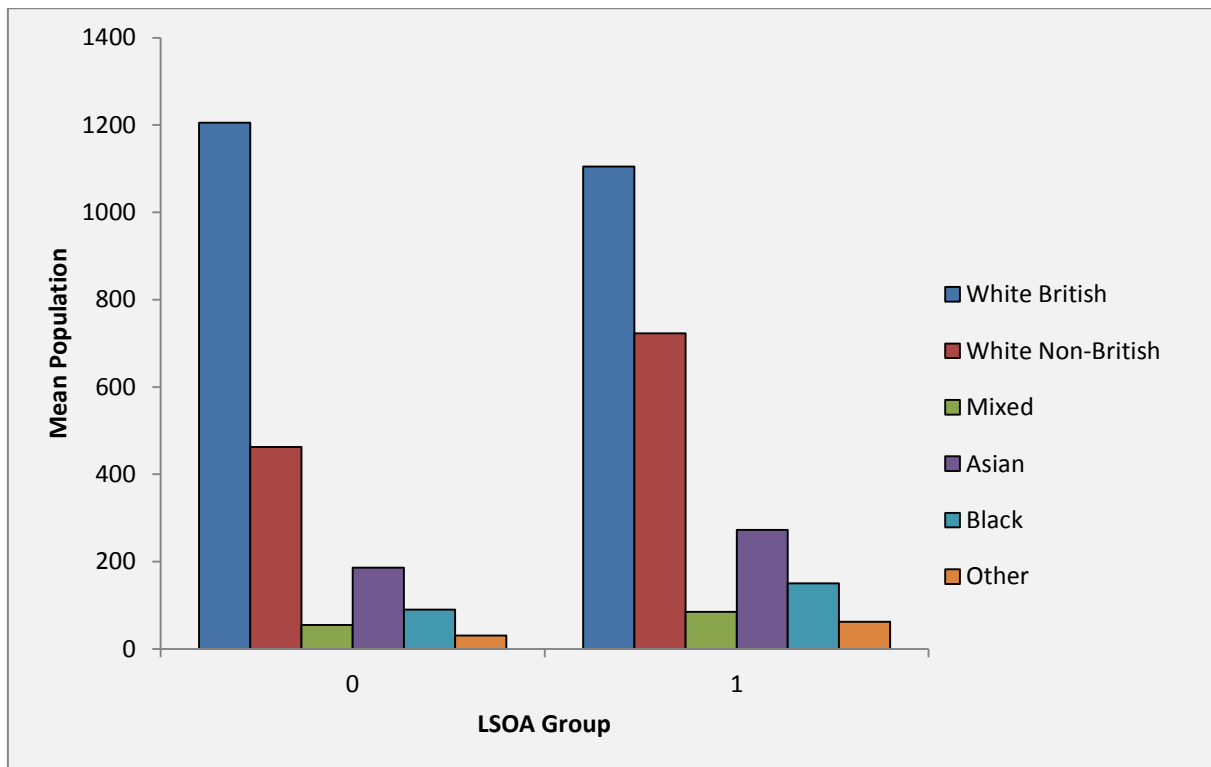
These data revealed that, of all OSEIs plotted, 78 (69%) occurred within five kilometres of Manchester City Centre (an area of 78.5km<sup>2</sup>) for a study area totalling 317.815km<sup>2</sup>,

suggesting that social-ecological innovation may be a highly urban, inner-city phenomenon. Nearest neighbour analysis (executed in ArcGIS.9) revealed that site distribution throughout the study area was highly clustered (ratio = 0.682; z-score = 6.47;  $P < 0.0001$ ).

Furthermore Figure 4.4 demonstrates that high population levels seemed to occur where OSEIs were found. In order to analyse OSEI demography in greater detail, LSOAs were separated into two groups: those where organised social-ecological innovation was present (Group 1) and those where it was not (Group 0). Comparing mean population density (persons per hectare) between Group 1 and Group 0, revealed that the localities of OSEIs bore a higher mean figure (mean = 55;  $\pm 35$ ) than the rest of the study area (mean = 52  $\pm 31$ ), but not at a significant level (Mann-Whitney U-test,  $p = 0.902$ ).

Demographic characteristics were explored further through analysis of cultural diversity exhibited in the LSOAs comprising the two groups. Analysis of the cultural diversity present in LSOA groups 1 and 2, was carried out by comparing the relative population size of each ethnic group using data and classifications from the 2011 UK census publication (namely, White British, White Non-British, Mixed, Asian, Black and Other). These data proved to be non-normally distributed and subsequent Mann-Whitney U-tests revealed that the two LSOA groups were highly statistically different for mean population across all categories of non-white British ethnicities (at the  $p < 0.001$  level) and for White British at the  $p = 0.001$  level. LSOAs with instances of organised social-ecological innovation (falling into Group 1) had higher mean populations for each ethnic group with the exception of White British as summarised in Figure 4.5.



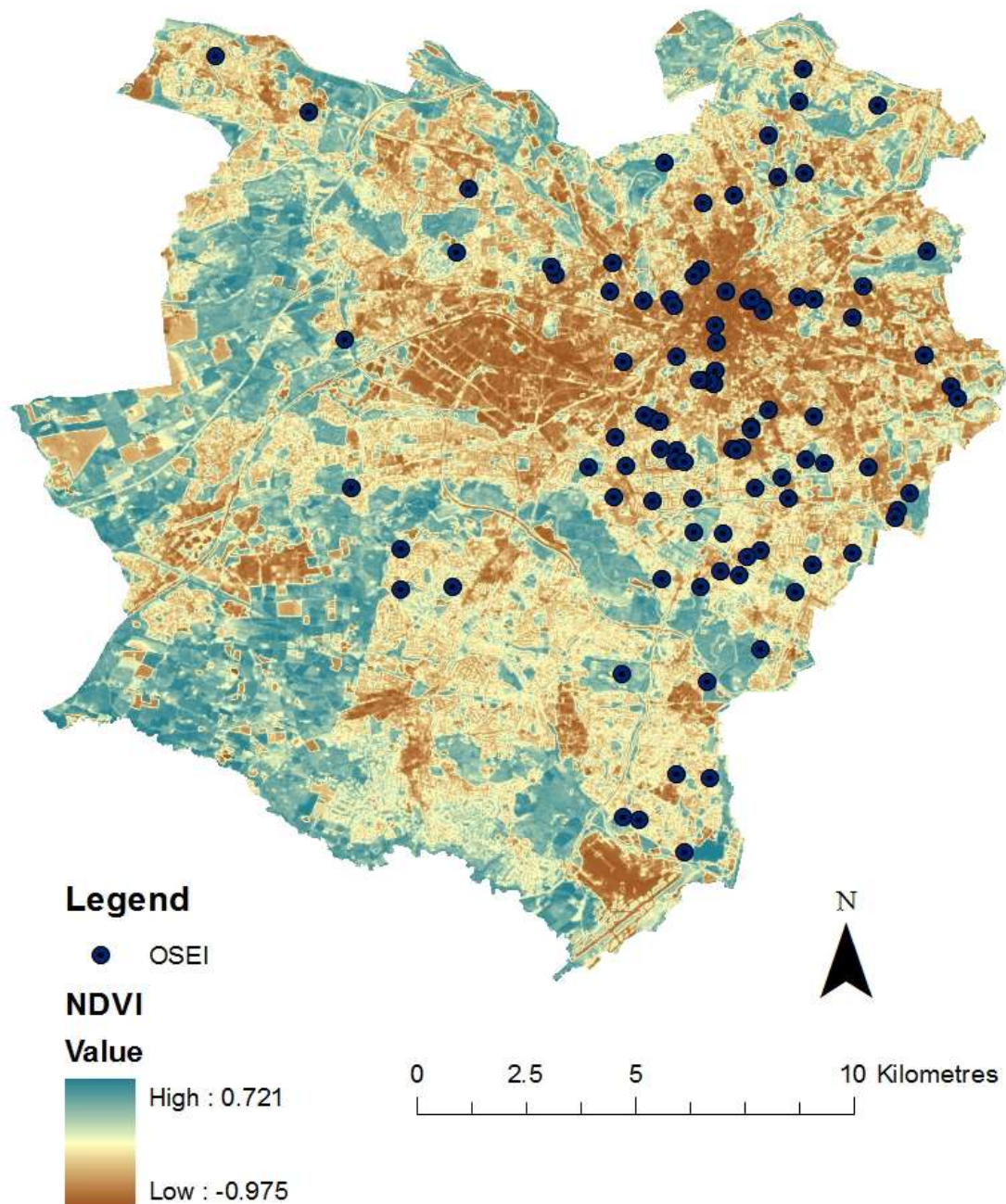


**Figure 4.5 LSOA ethnic group population (Group 0 = OSEI not found; Group 1 = OSEI found).**

These data were subsequently entered into a binary logistic regression analysis (backward conditional method) in IBM SPSS.20 to test the influence of population by ethnic group on whether a given area might contain instances of organised social-ecological innovation (i.e. testing for likely membership of Group 0 or Group 1). Data were entered as two variables: i) the majority (for all LSOAs) White British Population and ii) Non-White British population (i.e. all other categories), in units of 100 persons. Testing the final model against the constant only model proved to be statistically significant (Chi square = 19.57,  $p < 0.001$ ) and prediction success was 85% overall. The resulting (exp)B values concluded that in a given area, for every 100 persons increase in population *not* belonging to the majority White British group, there was an 11% increase in likelihood that organised social-ecological innovation would be found. Variation in White British population did not demonstrate significance and was removed from the final model (at  $p = 0.739$ ).

### **4.2.3 Land-cover analysis**

Following the initial exploration of the administrative and demographic data available, environmental data were applied to the analysis to assess co-occurrence of different land use types with OSEIs. Figure 4.6 shows sites plotted on a base-map layer of Normalised Difference Vegetation Index (NDVI) to give an indication of vegetative extent across the study area.



**Figure 4.6 OSEI distribution and normalised difference vegetation index (ONS, 2001; NASA, 2013).**

Based on the vegetative cover in Figure 4.6 it appeared that many of these central sites occurred in areas with a relatively low vegetative index and high levels of urbanisation. Sections immediately to the west of the city centre and the southern-most tip of the study

area, although seemingly highly built-up areas, showed little evidence of OSEI. This can be explained by the fact that these areas contained massive, non-residential infrastructural features; namely, Trafford Industrial Park to the west and Manchester Airport to the south. To explore further the ecological context of the spatial distribution of OSEIs, land cover data were obtained from Office for National Statistics (ONS, 2005) and surface sealing density was calculated for all LSOAs across the study area ( $\text{m}^2 \text{1000m}^{-2}$ , Figure 4.7). Building cover density for each Lower Super Output Area in the study area was also produced (Figure 4.8).

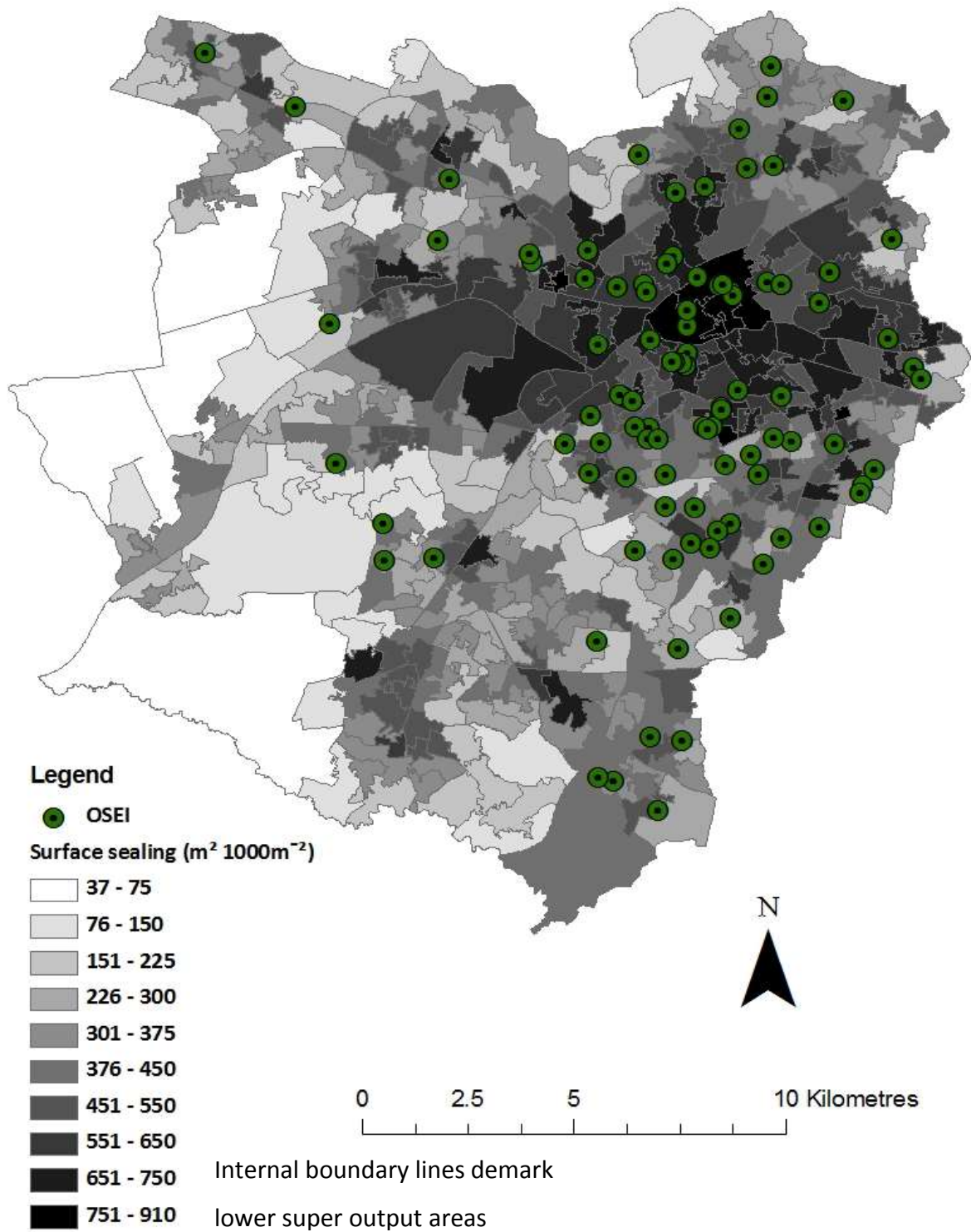


Figure 4.7 Study area surface sealing density ( $m^2$  1000 $m^{-2}$ ) by LSOA (ONS, 2001).

In terms of surface sealing  $1000\text{m}^{-2}$ , independent t-test between LSOAs containing OSEIs (Group 1) and those without (Group 0) revealed highly significant mean differences ( $t(539) = 3.09$ ;  $p = 0.002$ ) with a mean value for surface sealing in OSEI locations (Group 1) of  $468\text{m}^2 \pm 172\text{m}^2$  against the Group 0 mean of  $407\text{m}^2 \pm 158\text{m}^2$ .

Data was also available on building cover and entered into the analysis. The variance in extent of building cover per  $1000\text{m}^2$  for between Groups 1 and 0 was not statistically significant (Mann-Whitney U-test,  $p = 0.943$ ). These data are visualised in Figure 4.8.



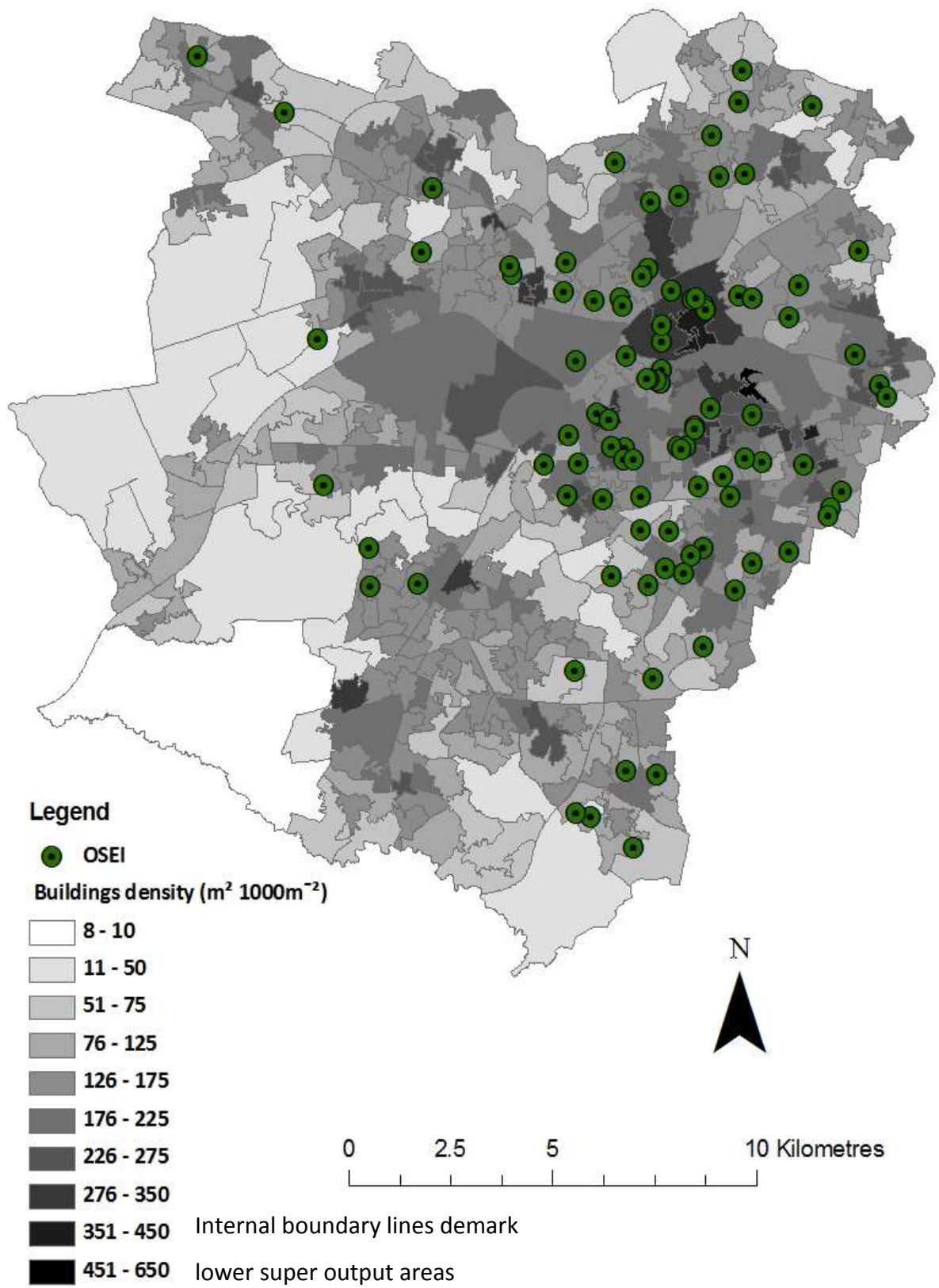


Figure 4.8 Study area buildings cover density ( $m^2 1000m^{-2}$ ) by LSOA (ONS, 2001).

As the data presented evidence to suggest that social-ecological innovation was likely to occur in more densely built-up areas, data on green space cover were obtained to add greater detail to the analysis. Sites were plotted on layers of public green space cover ( $\text{m}^2$   $1000\text{m}^{-2}$ ) and similarly for domestic gardens as presented in Figures 4.9 and 4.10.



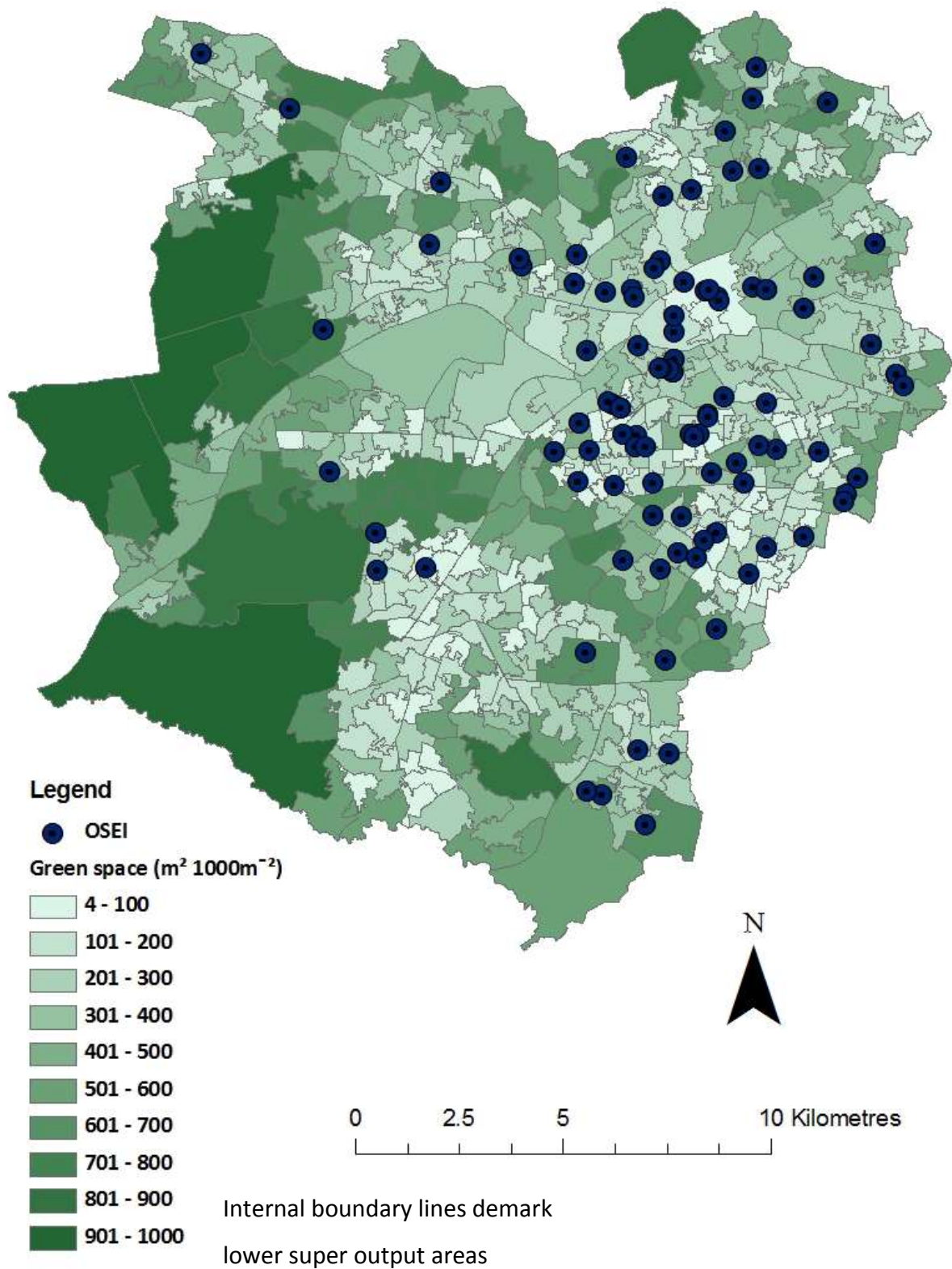


Figure 4.9 Study area green space density ( $m^2$   $1000m^{-2}$ ) per LSOA (ONS, 2001).

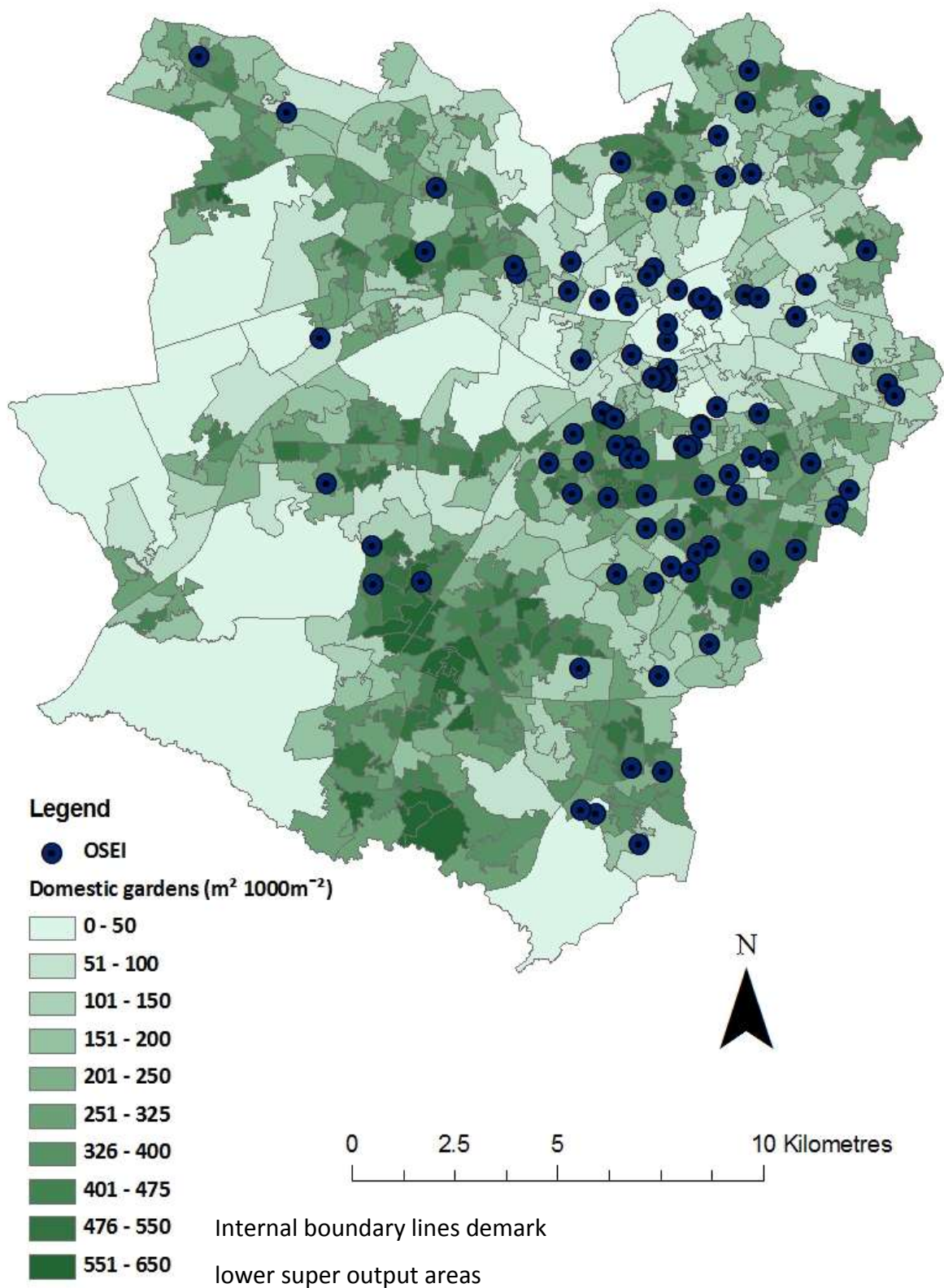


Figure 4.10 Study area domestic gardens cover ( $m^2 \ 1000m^{-2}$ ) per LSOA (ONS, 2001).

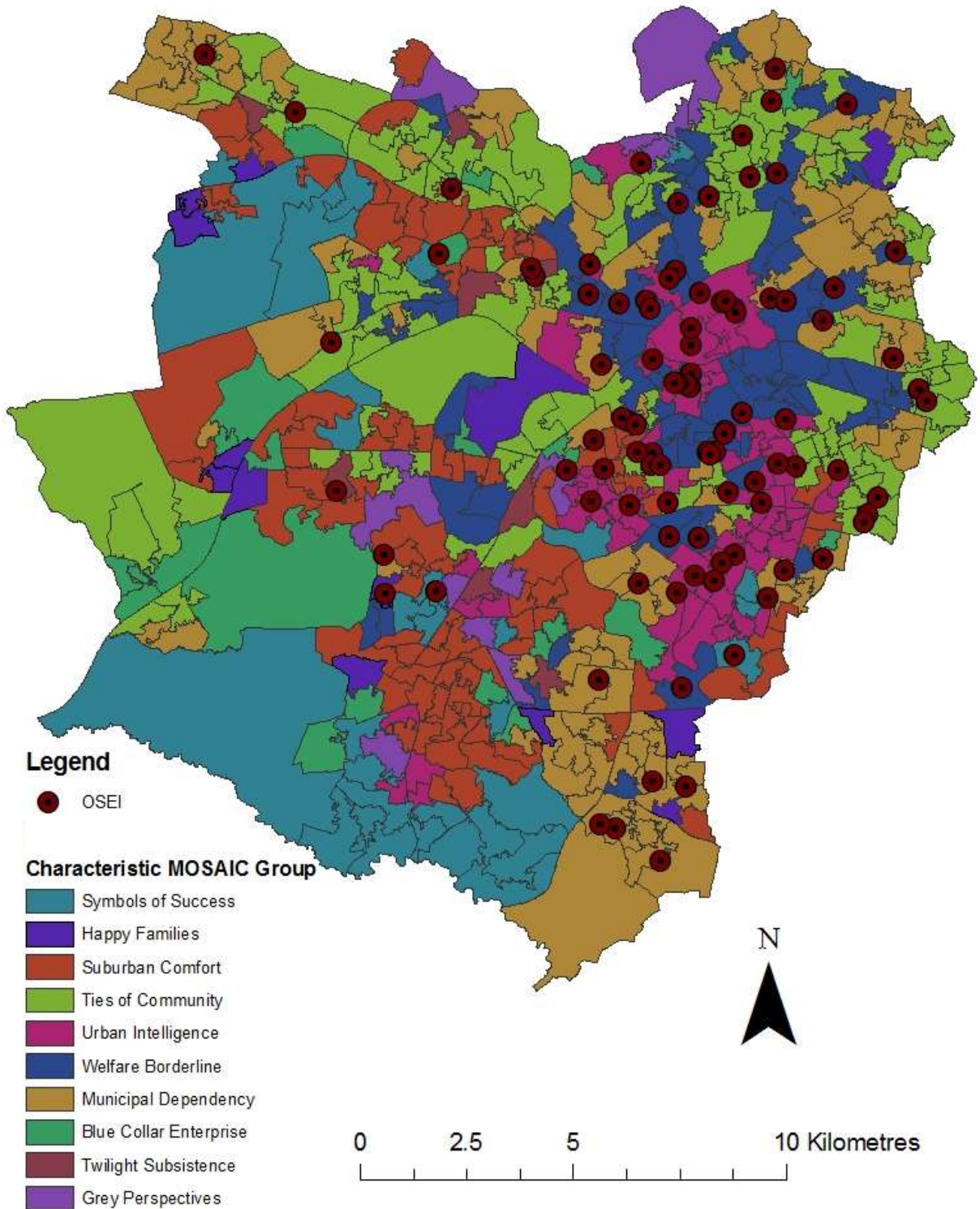
In terms of public green space, areas containing OSEIs were not found to be statistically discrete from the remainder of the study area mean for area cover per 1000m<sup>2</sup> (Mann-Whitney U-test,  $p = 0.255$ ) a surprising result given that, conversely, the difference in surface sealing between the two was highly significant. Examination of domestic garden cover per 1000m<sup>2</sup>, on the other hand, by independent samples t-test, revealed a very high level of significance ( $t(539) = 4.074$ ;  $p < 0.001$ ) in the mean difference between OSEI localities (mean = 218m<sup>2</sup> ±144m<sup>2</sup>) and the rest of the study area (mean = 291m<sup>2</sup> ±148m<sup>2</sup>).

#### **4.2.4 Socio-economic analysis**

##### **i) Experian MOSAIC neighbourhood characteristics analysis**

In order to appreciate the role that social circumstance has to play in the engendering of social-ecological innovation, information on neighbourhood characteristics was obtained by way of Experian MOSAIC data (2009) and mapped against OSEI distribution. Again, as per the analysis in previous sections, LSOAs were separated into groups based on whether OSEIs had been recorded in that area (Group 1), or not (Group 0). Figure 4.11 shows the most representative MOSAIC category for each LSOA in the study area against OSEI distribution.

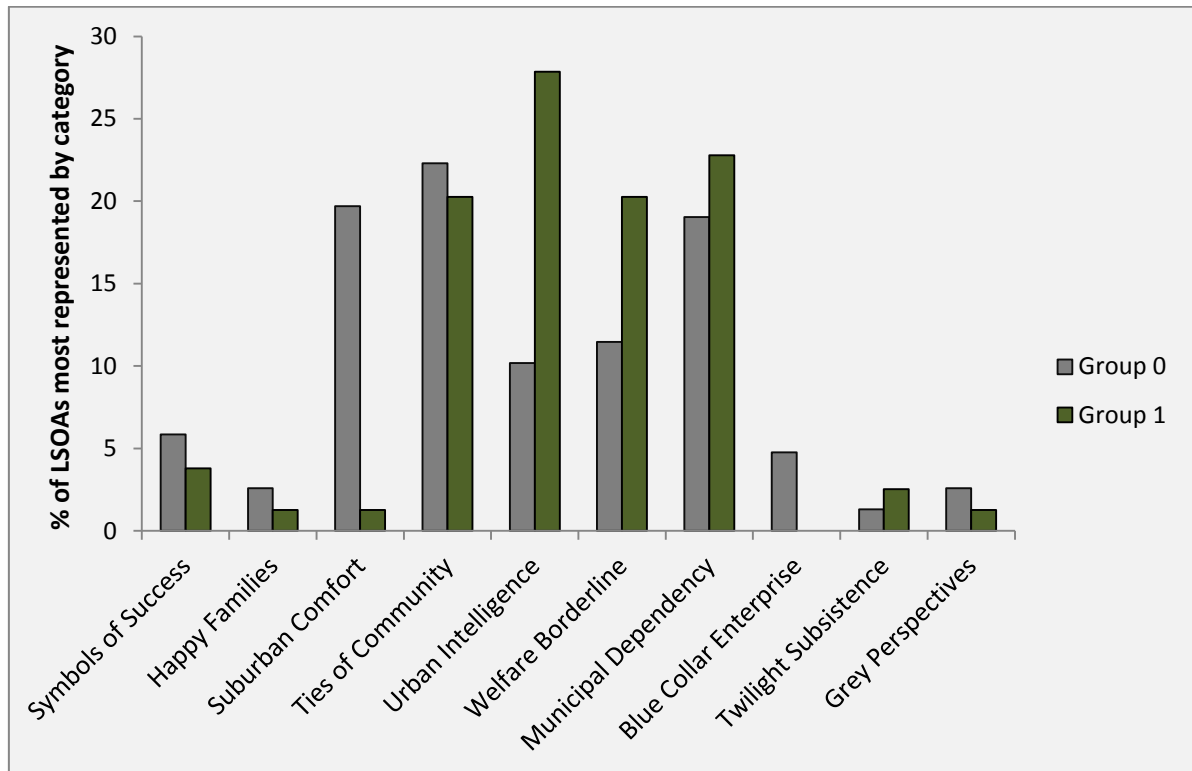




Internal boundary lines demark  
lower super output areas

**Figure 4.11 MOSAIC classification data: most representative category by LSOA (ONS, 2001).**

Chi-squared test revealed that the two groups were statistically discrete in terms of most representative MOSAIC household category (Pearson chi square = 37.99;  $P < 0.001$ ). These data are summarised by MOSAIC category (as percentage make-up of each group) in Figure 4.12.



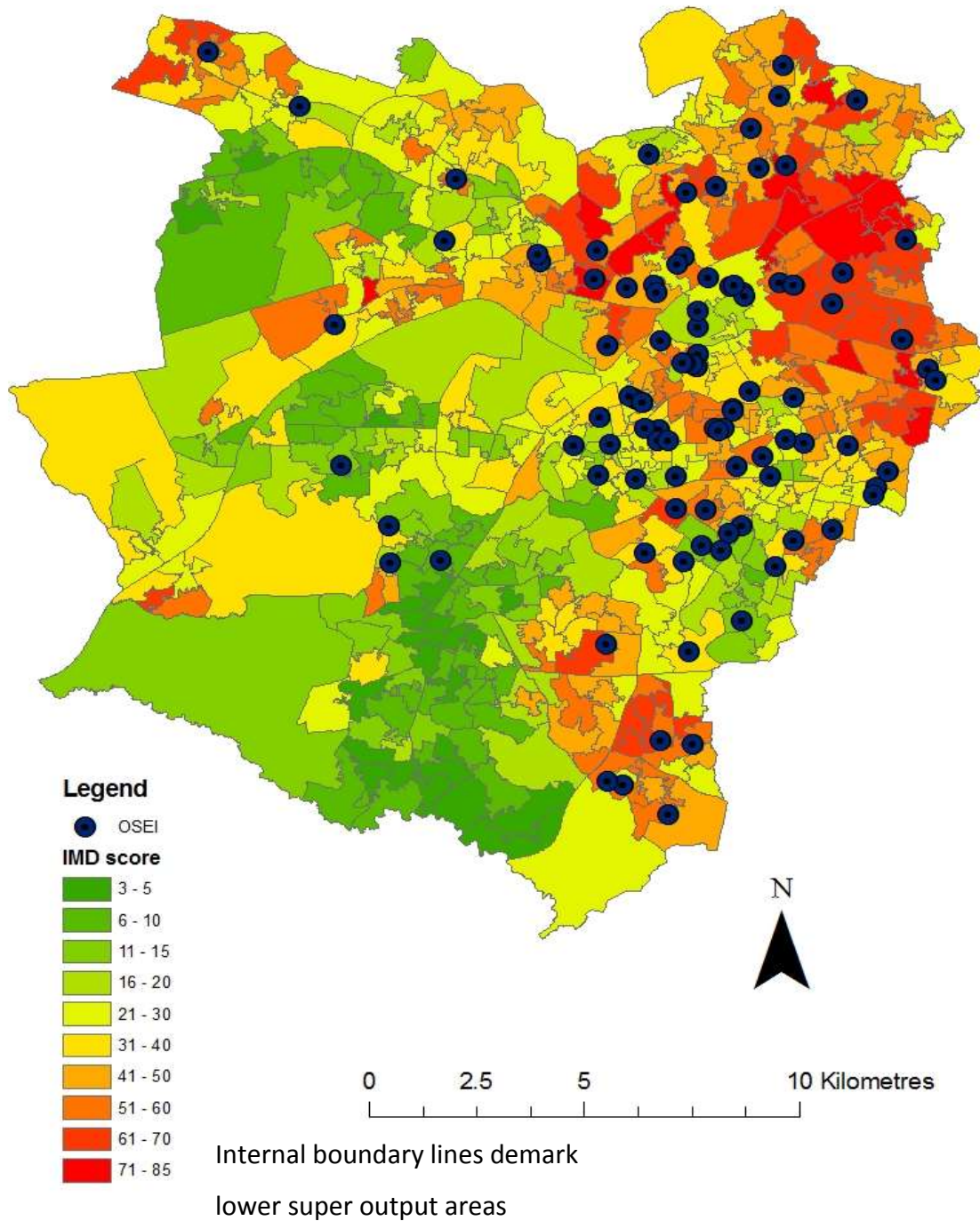
**Figure 4.12 Most represented MOSAIC households in LSOA Groups 0 (OSEI not found) and 1 (OSEI found).**

These data showed the two sample groups to differ most across MOSAIC categories three (Suburban Comfort), five (Urban Intelligence) and six (Welfare Borderline). Very few (1%) of LSOAs in Group 1, for example, were most represented by neighbourhoods in the Suburban Comfort category as opposed to almost 20% in Group 0. The MOSAIC typology (Experian, 2009) describes such households as occurring in affluent areas which are typically populated by successful white-collar workers and their families. On the other hand, Group 1 had a higher percentage representation for the categories Urban Intelligence and Welfare Borderline (28% and 20%) than did Group 0 (10% and 11%). According to the MOSAIC descriptors these households are inhabited by mainly young, educated students or career starters encumbered by debt and living in inner-city housing (in the case of “Urban Intelligence”) and by low-income, often state-dependent families in run-down areas which may suffer from high-levels of anti-social behaviour (in the case of “Welfare Borderline”).

These data therefore seemed to suggest a socio-economic divide between areas which contained instances of organised social ecological innovation, and those which did not.

**ii) Index of multiple deprivation analysis**

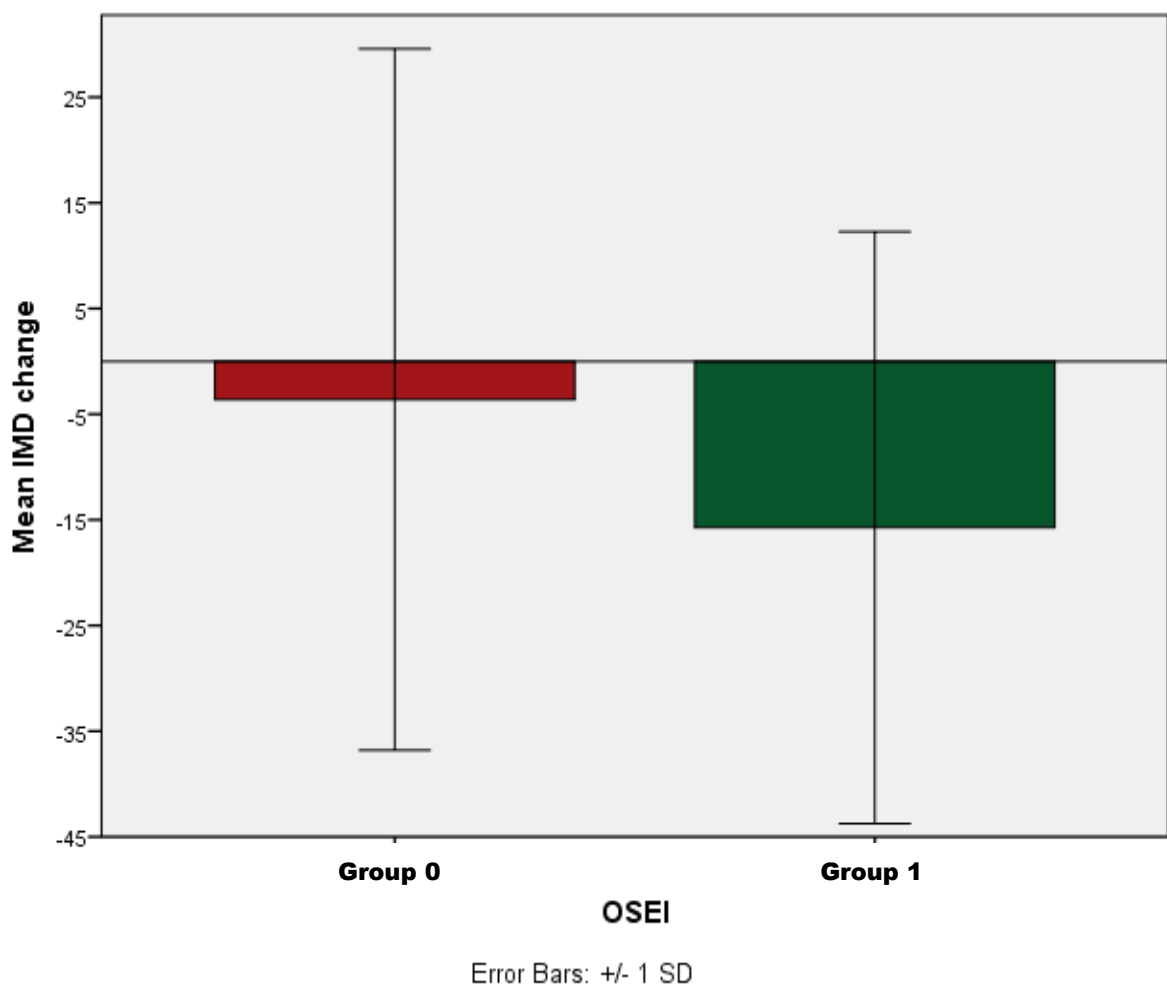
In order to investigate further the inferences from the MOSAIC analysis, sites were plotted against the most recent Index of Multiple Deprivation (IMD) scores from 2010 (Figure 4.13).



**Figure 4.13 Organised social-ecological innovation and IMD scores by LSOA (ONS, 2001).**

Analysis of mean Index of Multiple Deprivation scores for Group 1 LSOAs (mean = 39.03 ±17.06) against Group 0 (mean = 32.56 ±19.84) demonstrated a highly significant level of variance (Mann-Whitney U-test, p = 0.004) indicating that on the whole OSEI occurred in

areas that were subject to higher than average levels of deprivation for the study area. Comparing 2010 IMD data to the previous 2004 publication allowed for an analysis of area improvement according to increase or decrease in IMD score. These data demonstrated that Group 0 areas had improved within this time period (mean IMD change =  $-3.62 \pm 33.19$ ) but that localities of OSEIs (Group 1) presented a much greater mean improvement (mean change =  $-15.73 \pm 28.01$ ). The mean difference was significant at  $p = 0.002$  (Mann-Whitney U-test). This indicated that OSEIs had been occurring in areas that were improving, in deprivation terms, at a rate over 300% greater than the study area as a whole. This is illustrated in Figure 4.14 (with standard deviation error bars).



**Figure 4.14 Change in UK IMD score in Group 0 ("no"), and Group 1 ("yes").**

Mann-Whitney U-tests were also performed across the IMD domain indices: Income, Education, Employment, Health, and Crime and Disorder to add further detail to the analysis with p-values presented in Table 4.3 (significantly different domain scores are marked with asterisks \* =  $< 0.05$ ; \*\* =  $< 0.01$ ).



**Table 4.3 Group comparison p-values (Mann-Whitney U-test) across IMD domains.**

<b>Domain</b>	<b>p-value</b>
Income	0.025*
Employment	0.058
Education	0.232
Crime and Disorder	0.001**
Health	<0.001**

The tests demonstrated that although overall IMD score showed significant variation between values for OSEI locations and the remainder of the study area, the level of significance varied across the domains which make up the final Index score. In fact, mean levels of education and employment deprivation were not significantly different in the analysis with variation in Crime and Disorder, and Health Deprivation proving to be the most statistically significant between groups.

Of the ecological and socio-economic characteristics explored, two ecological (sealed surface density and domestic garden density) and two socio-economic (health deprivation, and crime and disorder score) differed significantly between the two groups at the  $p < 0.01$  level. This suggested that these ecological and socio-economic factors played an equally important role in providing the background conditions likely to fuel OSEI. Furthermore, certain elements studied presented weak but highly significant correlations (see Table 4.4), making judgement on the relative impact of each problematic.

**Table 4.4 Landscape parameter correlations.**

Spearman's rho		<b>Sealing Density</b>	<b>Income Deprivation</b>	<b>Health Deprivation</b>	<b>Crime and Disorder Deprivation</b>
<b>Garden Density</b>	Correlation Coefficient	-0.153	-0.255**	-0.292**	-0.350**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000
	N	541	541	541	541
<b>Sealing Density</b>	Correlation Coefficient		0.263**	0.312**	0.200**
	Sig. (2-tailed)		0.000	0.000	0.000
	N		541	541	541
<b>Income Deprivation</b>	Correlation Coefficient			0.876**	0.578**
	Sig. (2-tailed)			0.000	0.000
	N			541	541
<b>Health Deprivation</b>	Correlation Coefficient				0.634**
	Sig. (2-tailed)				0.000
	N				541

\*\* Correlation is significant at the 0.01 level (2-tailed).

#### 4.2.5 Integrated analysis of total environmental and socio-economic factors

The effects of the two social and ecological factors were delineated by combining elements of each into single scores for comparison. Ecological characteristics were combined to produce a figure for the proportion of total location (that is to say, LSOA) area which consisted of green land-cover types. The resulting variable, as a percentage, proved to be non-normally distributed (Kolmogorov-Smirnov:  $p = 0.02$ ) for Group 0 locations and the data were accordingly arc-sine transformed. Data for Groups 0 and 1 were subsequently entered into a two sample t-test to compare group means. Comparing OSEI localities against the rest of the study area revealed a highly significant mean difference ( $t(539) = 3.31$ ;  $p = 0.001$ ; mean difference =  $6.14\% \pm 3.75\%$ ). The data presented OSEIs as being in locations which, on average, contained a minority of green space versus hard-standing surfaces (with 66% of OSEIs occurring in areas with lower than 50% green space cover), whereas, for the study area in general, the reverse was true. Socio-economic data were consolidated by using overall IMD score as a measure of socio-economic context across the study area. The two

combined parameters proved to be significantly correlated ( $p < 0.001$ ; Spearman's rank correlation) but only to a weak degree ( $r^2 = 0.08$ ).

The two variables were then entered into a binary logistic regression model (forward stepwise likelihood ratio) to gauge the relative influence of each on the emergence of OSEI in the study area. The results of the regression are summarised in Table 4.5.

**Table 4.5 Binary logistic regression: ecological and socio-economic conditions as predictors of OSEI occurrence.**

		Variables in the Equation					
		B	S.E.	Wald	Df	Sig.	Exp(B)
Step 1 <sup>a</sup>	<b>% Green Space</b>	-0.041	0.013	10.559	1	0.001	0.960
	Constant	0.212	0.605	0.123	1	0.726	1.236
Step 2 <sup>b</sup>	<b>IMD Score</b>	0.013	0.006	3.935	1	0.047	1.013
	<b>% Green space</b>	-0.036	0.013	7.397	1	0.007	0.965
	Constant	-0.516	0.713	0.523	1	0.469	0.597
a. Variable(s) entered on step 1 % Green Space.							
b. Variable(s) entered on step 2: IMD Score.							

In terms of overall social and ecological conditions, the resulting stronger B and Exp(B) coefficients and lower significance value ( $p = 0.007$ ) exhibited by the ecological parameter (percentage green space: Table 4.5) presented this variable as being the more salient in predicting the occurrence of OSEI. This interpretation is supported by the fact that the green space cover variable had the greater influence of the two on the likelihood ratio when removed from the model (change in -2 log likelihood ratio = 7.44;  $p = 0.006$ , versus 3.92;  $p = 0.48$ ).

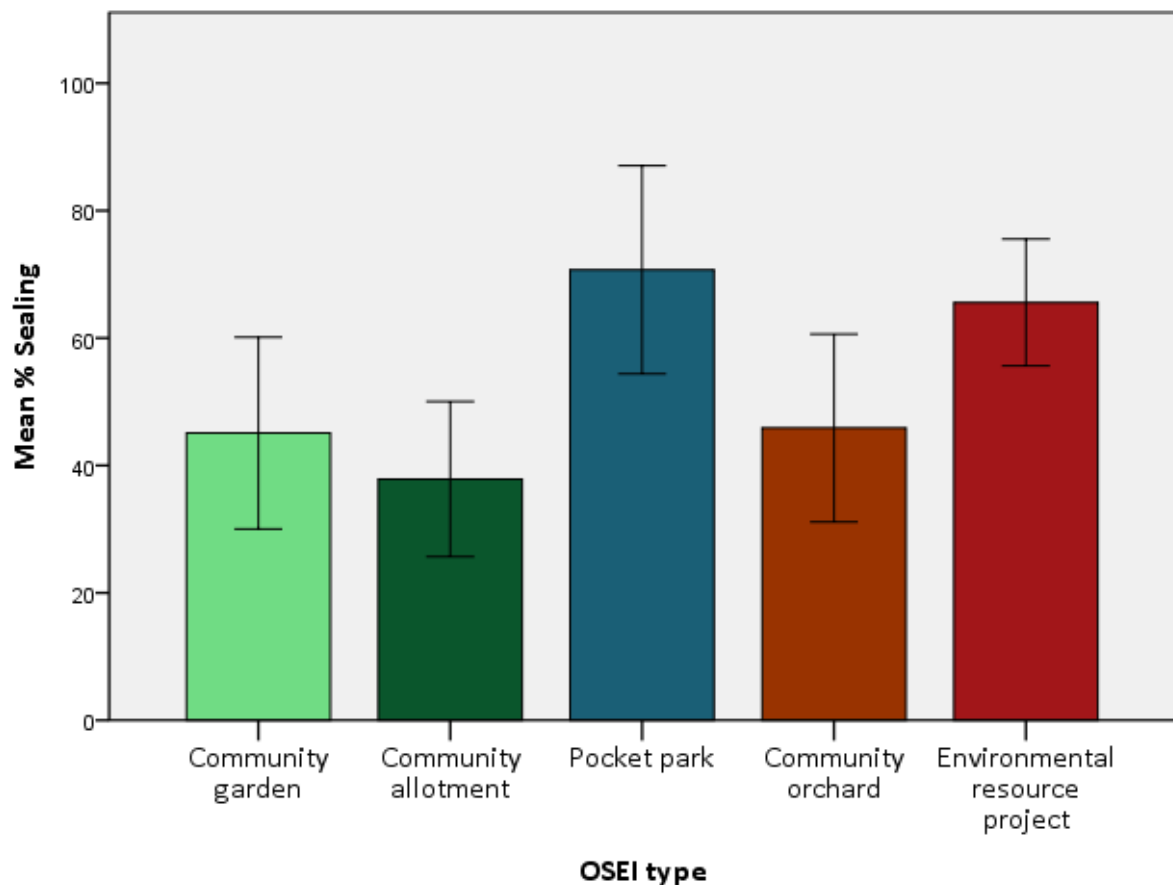
#### 4.2.6 Distribution of OSEI according to type

The analysis of the social-ecological context of OSEIs in Sections 4.2.2 to 4.2.4 revealed that levels of social and ecological deprivation were both significant in the occurrence of OSEI. This subsequently provided the basis for the analysis of the distribution of *types* of OSEI in the landscape. Given that levels of social-ecological deprivation were a key consideration, the locations of the discrete types of OSEI were explored by comparing levels of both social and ecological deprivation. In order to explore the spatial distribution of OSEIs based on their respective type (as detailed in section 4.2.1), data on ecological deprivation (as

percentage sealed surface cover) and socio-economic deprivation (IMD score) were analysed to evaluate the relative influence of each on the emergence of different types of OSEI. Again, the respective LSOA into which a given OSEI occurred was taken as the spatial context. Box-plot analysis revealed that the data for IMD score and proportion surface sealing followed normal patterns of distribution across types of OSEI and were entered into one-way ANOVA for analysis.

The result of the ANOVA revealed a significant mean difference across the localities of the five types of OSEI for percentage surface sealing ( $F(4) = 21.358$ ;  $p < 0.001$ ). Whereas, for IMD score, mean differences were not statistically significant ( $F(4) = 1.455$ ;  $p = 0.221$ ). Population density also demonstrated significant mean differences between type locations ( $F(4) = 2.507$ ;  $p = 0.046$ ).

Post-hoc testing (LSD) for proportion surface sealing revealed that pocket parks (mean = 71%;  $\pm 16\%$ ) and environmental resource projects (mean = 66%;  $\pm 10\%$ ) were the most homogenous types across this variable, both scoring above the grand mean of 51% and differing significantly from the other three OSEI types at the  $p < 0.05$  level. The biggest significant mean difference observed was 33% ( $p < 0.001$ ) between community allotments and pocket park locales. The means plot and a table summarising significant between-group mean differences are presented in Figure 4.15 and Table 4.6.



Error Bars: +/- 1 SD

**Figure 4.15 Means plot for ANOVA model: mean surface sealing (as percentage). Grand mean = 51% ±18%.**

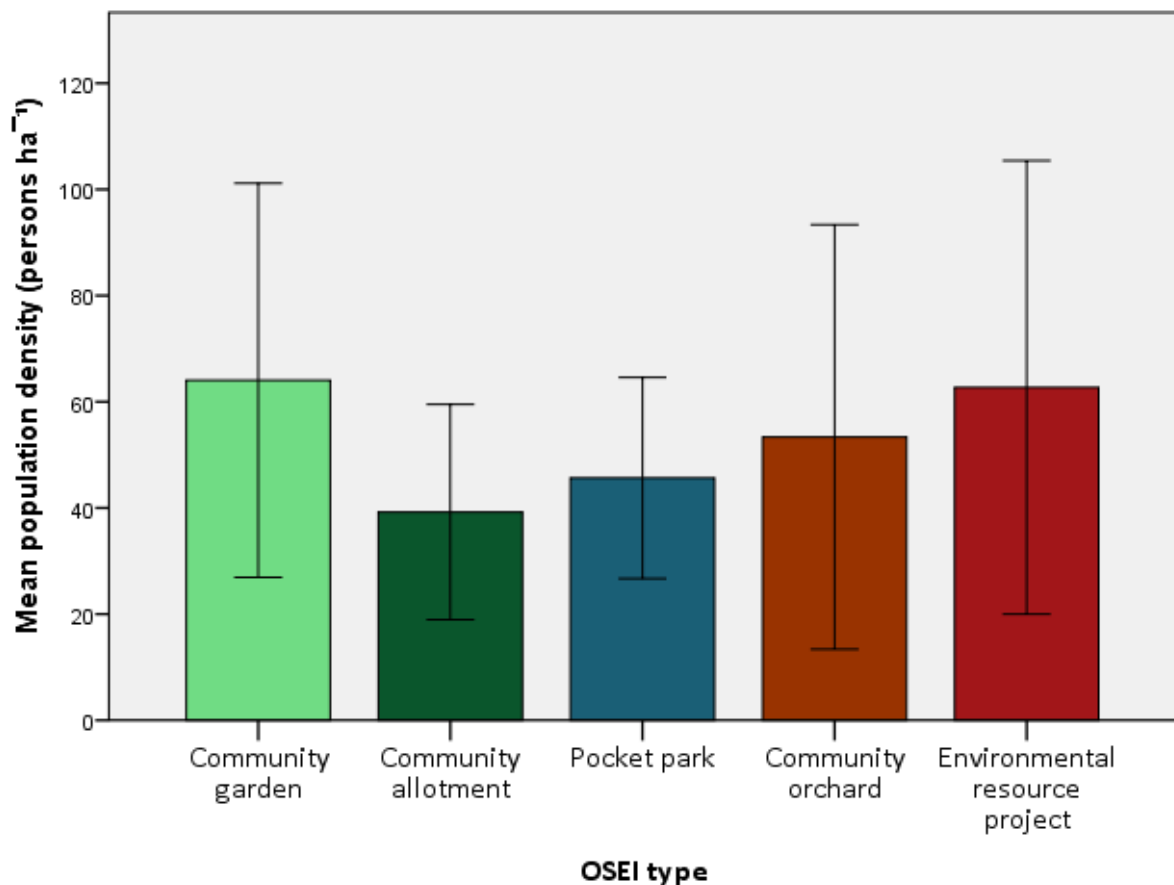
Significant mean differences in surface sealing were observed between pocket park locations and that of all other types with the exception of environmental resource projects. The latter likewise differed significantly from all types other than pocket parks. These two types were thereby the most statistically homogenous for this variable. All significant differences are summarised in Table 4.6.

**Table 4.6 Significant mean differences between OSEI type locations: proportion surface sealing.**

Type	Community allotment	Pocket park	Community orchard	Environmental resource project
Community garden	*	*	n.s.	*
Community allotment		*	n.s.	*
Pocket park			*	n.s.
Community orchard				*

**\*Significant at  $p < 0.05$  level; n.s. = not significant**

Mean population density across OSEI type locations also exhibited significant mean differences. The greatest significant mean difference was that between community garden locations ( $64 \text{ persons ha}^{-1} \pm 37$ ) and community allotments ( $39 \text{ persons ha}^{-1} \pm 20$ ). The means plot for this variable is presented in Figure 4.16.



Error Bars: +/- 1 SD

**Figure 4.16 Type locations: mean population densities.**

Two significant mean differences associated with area population density were revealed by post-hoc testing (LSD: Table 4.7).

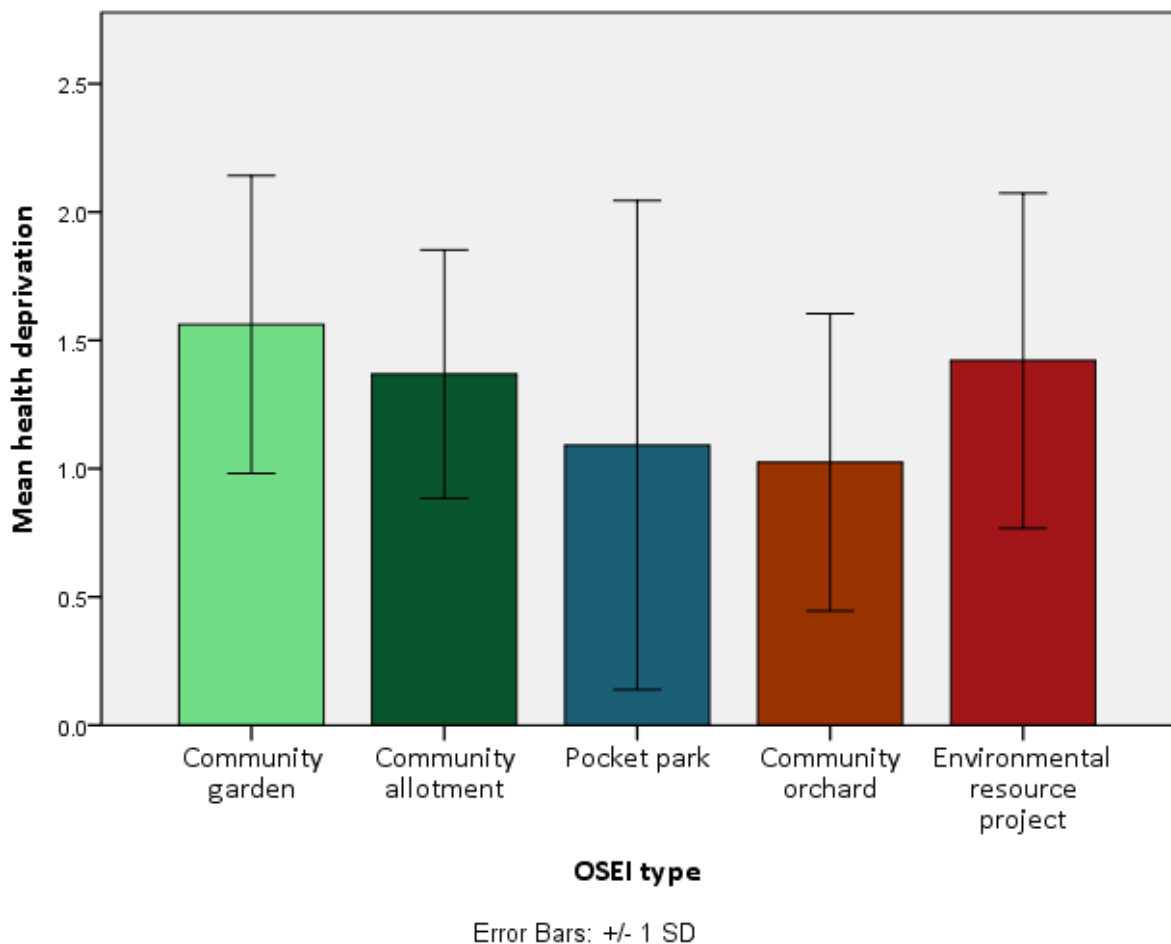
**Table 4.7 Type mean differences: population density.**

Type	Community allotment	Pocket park	Community orchard	Environmental resource project
Community garden	*	n.s.	n.s.	n.s.
Community allotment		n.s.	n.s.	*
Pocket park			n.s.	n.s.
Community orchard				n.s.

\*Significant at  $p < 0.05$  level; n.s. = not significant

Mean values for IMD score revealed that community orchards occurred on average in the least deprived areas (mean = 31.27 ±17.21) with pocket parks (mean = 36.37 ±18.08) also scoring below the OSEI sample mean score of 39.45. Community gardens and environmental resource projects tended to occur in more deprived areas with mean IMD scores of 41.95 ±16.86 and 42.97 ±16.41 respectively. Mean IMD score for community allotments was close to the OSEI grand mean at 38.38 ±13.66.

Although significant differences were not found for overall IMD score, discrepancies were observed across two of the IMD domains: Health Deprivation ( $F(4) = 2.606$ ;  $p = 0.04$ ) and Crime and Disorder ( $F(4) = 3.593$ ;  $p = 0.009$ ). Means plots for the two domains are presented in Figures 4.17 and 4.18 with significant between-group mean differences revealed by post-hoc tests (LSD) summarised in Tables 4.8 and 4.9.



**Figure 4.17 Type mean health deprivation scores. Grand mean = 1.37 ±0.66**

Post-hoc tests (LSD) for type mean health deprivation scores revealed two significant mean differences as summarised in Table 4.8.

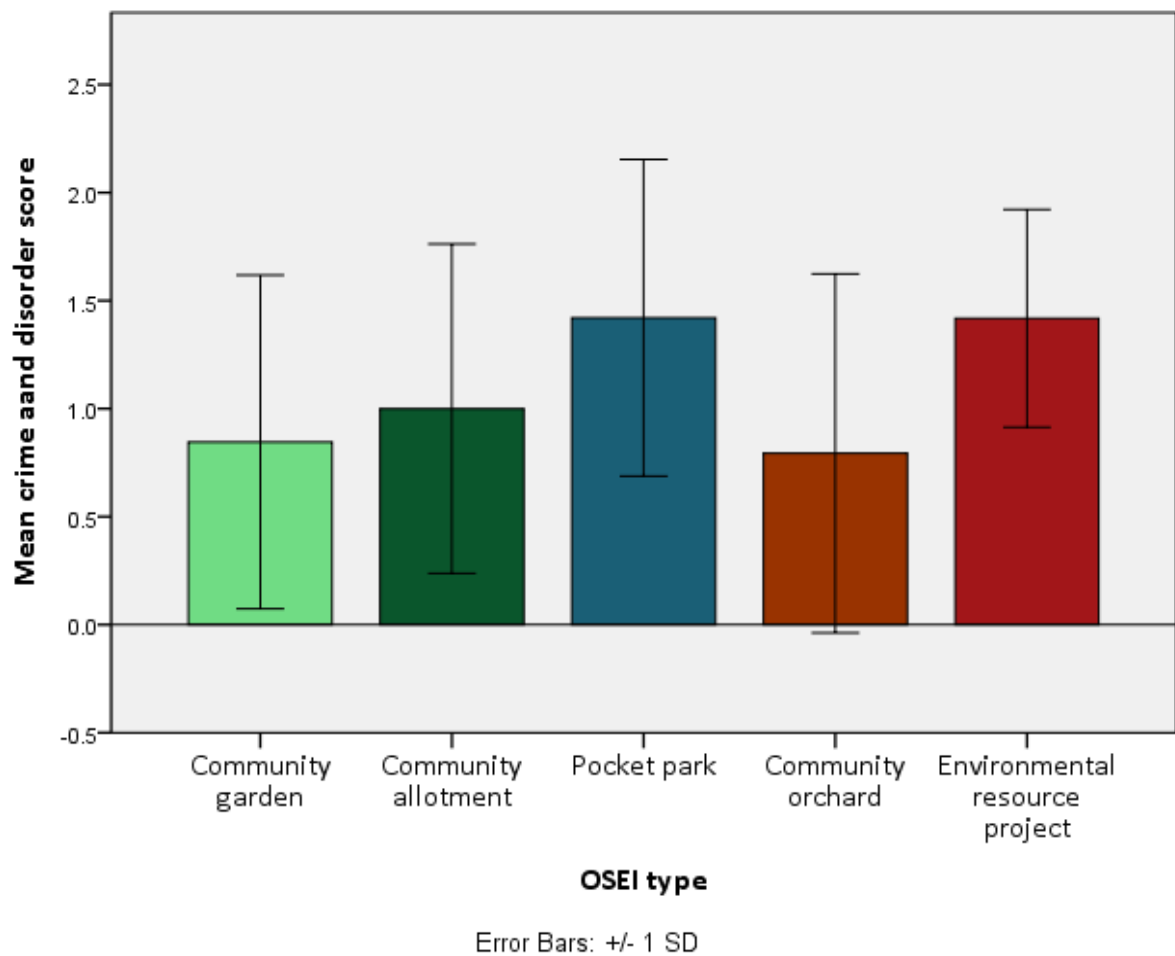


**Table 4.8 Significant mean differences between types: health deprivation.**

Type	Community allotment	Pocket park	Community orchard	Environmental resource project
Community garden	n.s.	*	*	n.s.
Community allotment		n.s.	n.s.	n.s.
Pocket park			n.s.	n.s.
Community orchard				n.s.

\* = Significant at  $p < 0.05$  level; n.s. = not significant

The means plot for type crime and disorder scores demonstrated a markedly different distribution than for health deprivation (Figure 4.18).



**Figure 4.18. Type mean crime and disorder deprivation scores. Grand mean =  $1.06 \pm 0.76$ .**

Post-hoc tests across crime and disorder deprivation scores revealed greater disparity between types than did health deprivation with four significant mean differences (Table 4.9).

**Table 4.9 Significant mean differences between types: crime and disorder.**

Type	Community allotment	Pocket park	Community orchard	Environmental resource project
Community garden	n.s.	*	n.s.	*
Community allotment		n.s.	n.s.	n.s.
Pocket park			*	n.s.
Community orchard				*

\* = Significant at  $p < 0.05$  level; n.s. = not significant

As can be seen in Figures 4.17 and 4.18, mean levels of health deprivation and those for crime and disorder deprivation described a markedly different distribution across types. In particular, the most noticeable contrast was exhibited by mean scores for crime and disorder and those for health in locations where pocket parks were recorded. These areas, counter-intuitively, exhibited the lowest level of deprivation for health relative to other type locations (Figures 4.17) whilst simultaneously being subject to some of the highest levels of crime and disorder in the sample (Fig. 4.18). Community garden localities exhibited the inverse of this pattern. These locations presented some of the highest levels of deprivation overall whilst scoring the lowest of all OSEI types for crime and disorder.

Analysis of the results presented ecological factors overall as being the more significant in terms of delineating the areas where different types of OSEI were recorded. This was illustrated by greater incidence of significant between-type differences for proportion sealing than for demographic or socio-economic variables (Tables 4.6 to 4.9). To confirm this inference data on land-cover density values for domestic gardens, surface sealing and buildings, the Index of Multiple Deprivation domain indices: Income, Health, and Crime and Disorder, as well as data on population density were entered into a discriminant function analysis. The first function of the discriminant analysis produced an eigenvalue of 1.14 and accounted for 73% of the variation between types, with a canonical correlation of 0.73. Surface sealing, domestic garden cover and buildings density exhibited the highest

correlations within the first function, presenting physical characteristics as the most significant in classifying type locations. Cross-validation analysis revealed that 52% of group cases were correctly classified, a 126% improvement on prior probability estimates, lending satisfactory credence to the model. The model's structure matrix is presented in Table 4.10.

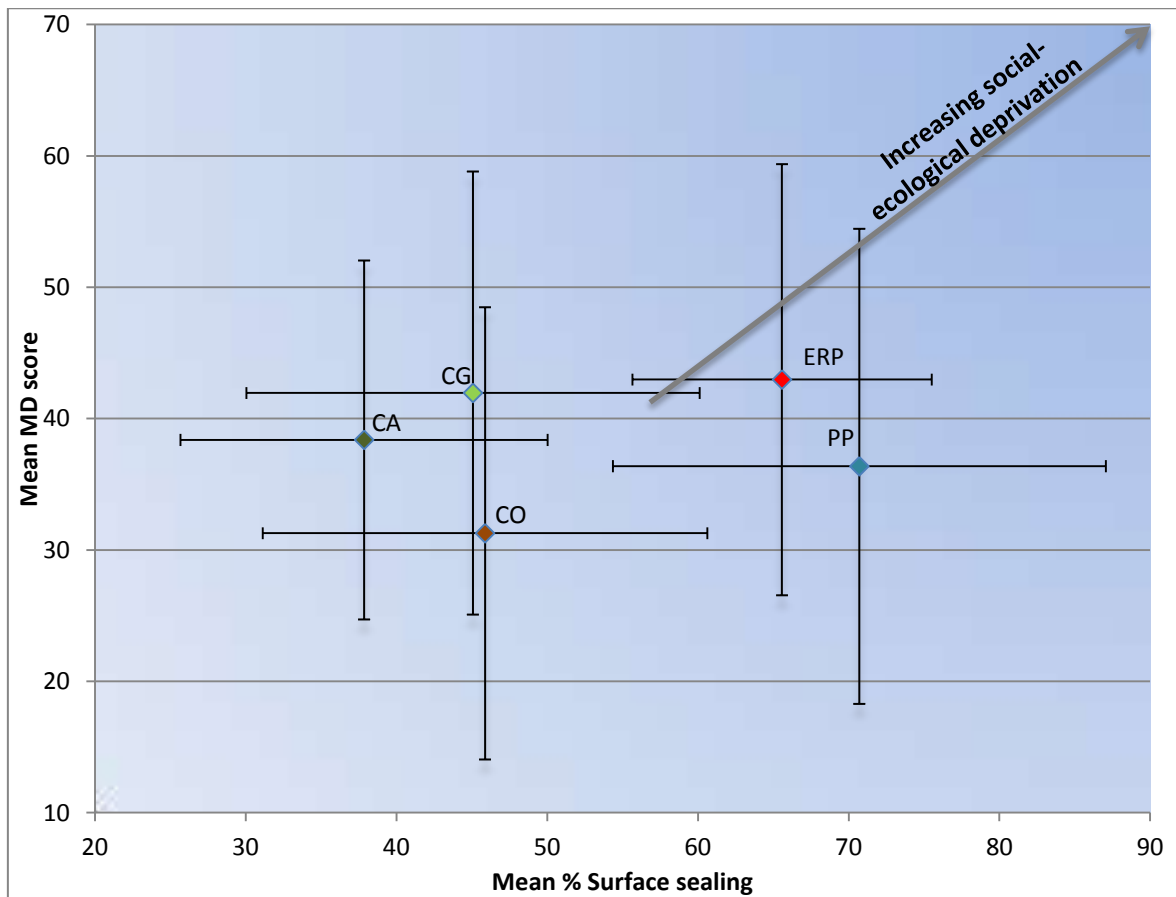
**Table 4.10 Discriminant function analysis: structure matrix.**

	Function			
	1	2	3	4
<b>Surface sealing</b>	0.806*	0.355	0.302	-0.175
<b>Gardens density</b>	-0.557*	0.239	0.409	-0.469
<b>Population density</b>	-0.017	0.529*	0.182	-0.378
<b>Buildings density</b>	0.442	0.236	0.565*	-0.208
<b>Health deprivation</b>	-0.138	0.399	-0.093	0.850*
<b>Income deprivation</b>	-0.041	0.436	-0.382	0.559*
<b>Crime and disorder</b>	0.319	0.019	-0.304	0.481*

\* Largest absolute correlation between each variable and any discriminant function.

#### **4.2.7 Dynamics of social-ecological deprivation.**

The presentation of OSEI types in the means plots for surface sealing and IMD domain scores (Figures 4.15, 4.17 and 4.18) suggested that environmental resource projects occurred in areas with the highest levels of combined social and ecological deprivation with mean values above those of the OSEI sample for both surface sealing and IMD variables. An appreciation of the mean degree of social-ecological deprivation extant in OSEI-type localities was enabled by plotting type means for surface sealing against that for IMD score which drew out the relative character of each. These are presented in Figure 4.19 (with standard deviation error bars).



Key: CG = community garden; CA = community allotment; PP = pocket park; CO = community orchard; ERP = environmental research project

**Figure 4.19 OSEI type and degree of combined social-ecological deprivation.**

To give an indication of the range of the social and ecological conditions in which examples of OSEI were found in the study area, the ranges of IMD score and percentage surface sealing were compared for OSEI locations and the study area as a whole and are summarised in Table 4.11.

**Table 4.11 OSEI and study area comparison: descriptive statistics.**

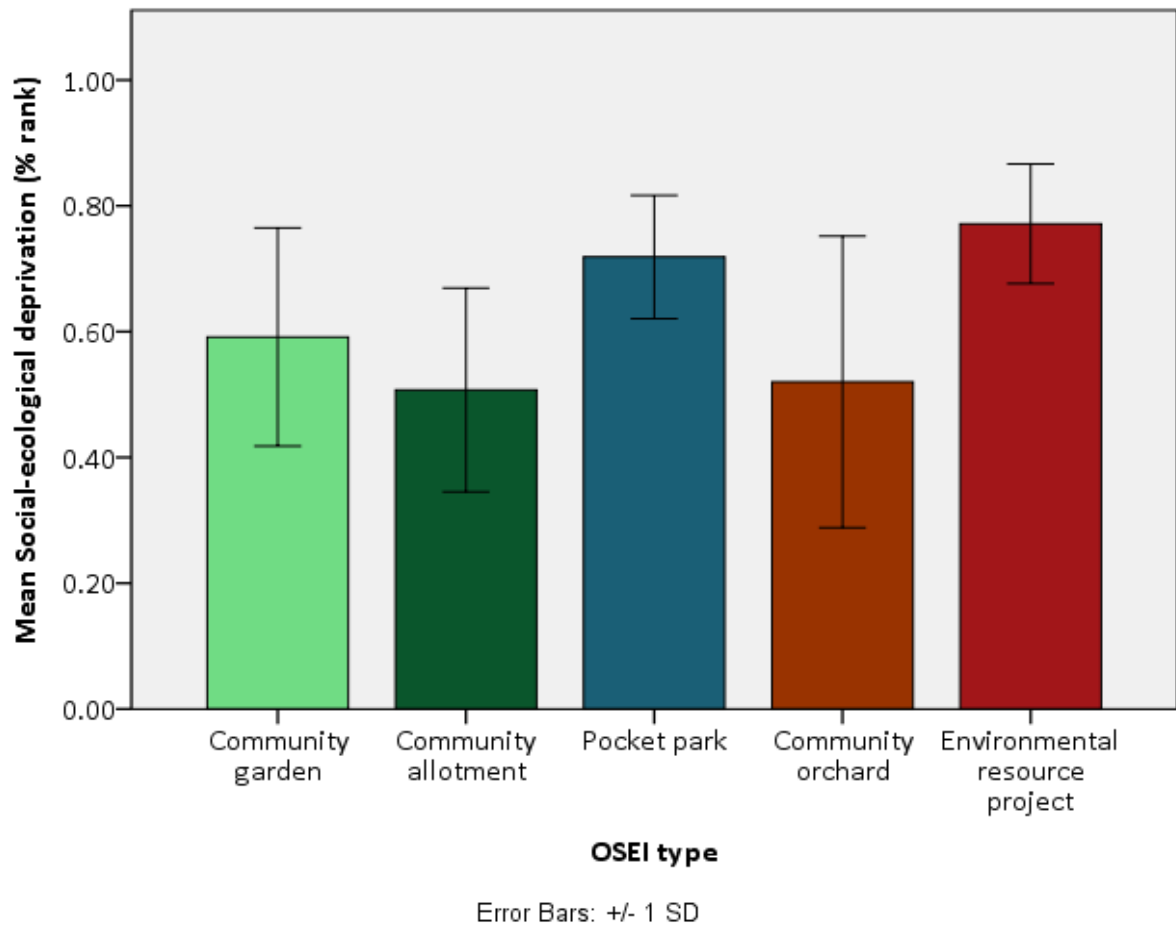
	Minimum	Maximum	Mean	Std. Deviation
<b>Study Area</b>				
Proportion Sealing	3.71	90.73	41.62	16.17
IMD Score	2.61	81.58	33.51	19.58
<b>OSEI locations</b>				
Proportion Sealing	15.89	90.73	51.10	18.12
IMD Score	6.73	79.65	39.45	16.52

The summary statistics presented in Table 4.11 illustrate the range of conditions in which examples of OSEI were found. Importantly, the data here demonstrate that OSEIs were recorded in very highly socially deprived areas (IMD score max. = 79.65; Study area max. = 81.58) and also in the most ecologically deprived locations at surface sealing values of 90.73% (study area max. = 90.73%). However, the arrangement of OSEI types as presented in Figure 4.19 suggests that, other than in the case of environmental resource projects, OSEIs were, on the whole, not commonly found in areas that were subject to both extremes of social and ecological deprivation.

The relative position of OSEI types presented in Figure 4.19 suggested that localities of environmental resource projects were subject to the highest degree of combined social and ecological deprivation. This was clarified by calculating the percent rank of each OSEI location relative to the whole study area for both IMD score and surface sealing. The mean of these two values was subsequently taken as a relative measure of the combined social-ecological deprivation at OSEI locations. A univariate analysis of variance in IBM SPSS.20 was then performed on the resulting OSEI social-ecological deprivation measures. The test proved to be significant at the  $p < 0.001$  level ( $F(4) = 10.945$ ). Descriptive statistics, type means and pair-wise comparisons (LSD) are presented in Table 4.12, Figure 4.20 and Table 4.13 respectively.

**Table 4.12 OSEI type location social-ecological deprivation: descriptive statistics.**

<b>OSEI Type</b>	<b>Mean</b>	<b>N</b>	<b>Standard Deviation</b>	<b>Minimum</b>	<b>Maximum</b>
<b>Community gardens</b>	0.59	40	0.17	0.18	0.87
<b>Community allotments</b>	0.51	23	0.16	0.24	0.78
<b>Pocket parks</b>	0.72	15	0.10	0.60	0.91
<b>Community orchards</b>	0.52	13	0.23	0.18	0.88
<b>Environmental resource project</b>	0.77	22	0.10	0.57	0.91
<b>Total</b>	0.62	113	0.18	0.18	0.91



**Figure 4.20 Mean deprivation percentile rank for OSEI type locations.**

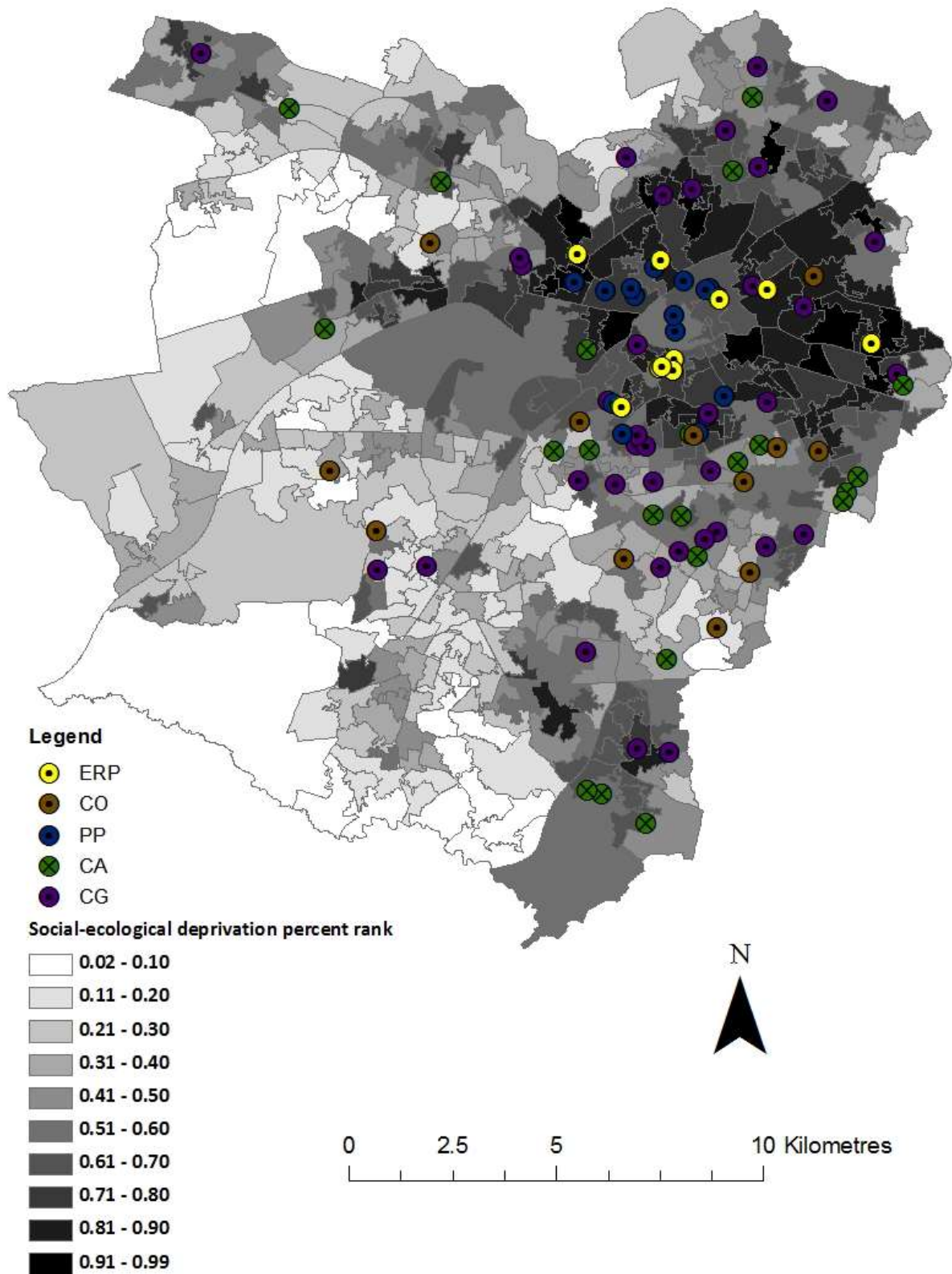
Between-type comparisons for combined social-ecological deprivation at OSEI locations revealed that pocket parks and environmental resource projects were the most statistically homogenous types for this variable, both differing significantly with those of community gardens, community allotments and community orchards (Table 4.13).

**Table 4.13 Social-ecological deprivation significant type mean differences.**

Type	Community allotment	Pocket park	Community orchard	Environment resource project
Community garden	*	*	n.s.	*
Community allotment		*	n.s.	*
Pocket park			*	n.s.
Community orchard				*

**\*Significant at p <0 .05 level; n.s. = not significant**

The statistical analysis confirmed that environmental resource centre localities exhibited the greatest degree of combined social-ecological deprivation of the OSEI types defined in the study area. The measure for social-ecological deprivation for each LSOA in the study area was joined to administrative boundary data within ArcGIS.9, and OSEIs were plotted against the resulting layer, according to type, as presented in Figure 4.21.



Key: ERP = environmental resource project; CO = community orchard; PP = pocket park; CA = community allotment; CG = community garden.

**Figure 4.21 Relative levels of social-ecological deprivation and types of OSEI (ONS, 2001).**



Figure 4.21 revealed that, although social and ecological deprivation were complicit in the development of OSEI, there were areas seemingly at the upper limits of social-ecological deprivation for the study which did not contain OSEIs.

The maximum percentile rank of social-ecological deprivation for OSEI localities as presented in Table 4.11 was 0.91. Accordingly, the study area contained LSOAs with degrees of social-ecological deprivation beyond the upper limits of those which contained OSEIs. Mean differences in IMD score and proportion surface sealing between OSEI locations and those areas above the percentile rank cut-off of 0.91 where OSEI was absent, were explored using comparison of means (independent samples t-test) in IBM SPSS.20. The test revealed that LSOAs subject to levels of social-ecological deprivation above the maximum levels exhibited by OSEI locations ( $n = 12$ ) bore higher mean values which were significantly different from the latter both in terms of surface sealing ( $t(70) = -8.97$ ;  $p < 0.001$ ; mean difference =  $20.77 \pm 4.62$ ;  $d = 2.14$ ;  $r = 0.73$ ), and IMD score ( $t(45) = -11.14$ ;  $p < 0.001$ ;  $d = 3.32$ ;  $r = 0.86$ ; mean difference =  $28.77 \pm 2.20$ ). The data therefore demonstrated that, at the upper extremes of social-ecological deprivation in the study area, OSEI did not occur above a certain level and that both social and ecological factors were significant in determining this threshold. The greater effect size exhibited by IMD score ( $r = 0.86$ ) relative to surface sealing ( $r = 0.73$ ) suggests that the former element of deprivation was particularly instrumental in preventing the emergence of OSEI. This inference was supported by analysis of data relating to MOSAIC group households for which areas above a percentile rank of 0.91 for social-ecological deprivation were distinctly divergent from OSEI localities. Among the former, there were none which were most highly represented by Category 5 (Urban Intelligence) households. This was in stark contrast to LSOAs containing OSEIs, where this was on average the most highly represented of all groups (with 28% of LSOAs most characterised by Category 5).

## **4.3 Discussion of the mapping exercise**

### **4.3.1 Social-ecological innovation and urban agriculture**

The mapping exercise revealed that a clear majority of examples of organised social-ecological innovation were involved in land-based, horticultural activities (Section 4.2.1), with a similar majority demonstrating some degree of food cultivation as one of the primary activities. This confirms some of the assumptions that were inferred from the literature review and addresses research objective 2 of this thesis, showing clearly that food as social-ecological concern and a reified connection to the land through its cultivation was a key catalyst in the occurrence and design of social-ecological innovation in the study area. Being that a majority of sites were involved in some form of UA, to a greater or lesser extent, it can be seen that the cornerstone of OSEI management was the cultivation of food. In this way, food can be seen as a powerful conduit for social-ecological innovation. It is a subject of social, political, economic and environmental importance that impacts the human and natural landscape at local and global scales and everything in between (see Section 2.8). As such, it is no surprise that the majority of community horticultural endeavours take food production as their primary practice. Not only is food pertinent and extremely topical as a “subject” but on a concrete, physical level, it is what ties humans inescapably to the land. Its cultivation appeals both to our immediate, somatic experience as well as to a more conceptual appreciation of the environment and our place within it.

Of those sites recorded, the majority (35%) were community gardens (Table 4.1). This demonstrated that community gardens, as a form of organised social-ecological innovation, are the most common medium by which such innovation found place in the study area. This type of OSEI was, according to the distribution presented in Figure 4.21, also that which exhibited the most extensive range in the landscape, both geographically and in terms of social-ecological conditions. The reasons for this were not clear after the culmination of the mapping exercise though this matter is explored further in the case-study analysis which is presented in Chapter 5 of this thesis.

### **4.3.2 Locations of OSEIs**

#### **i) Demographic characteristics**

According to the data in Figures 4.2 and 4.3, the majority of OSEIs (73%) were located in the City of Manchester and a similar share (69%) was found no more than five kilometres from the city centre. This apparent clustering of sites around this central zone held for the distribution of sites throughout the study area as revealed by the nearest neighbour analysis detailed in section 4.2.2. Given the clustered appearance of OSEIs, the creation and distribution of OSEI in the landscape were clearly influenced by an element of social-ecological networking, either organised or incidental, at play in its emergence and distribution.

This would also imply that social-ecological innovation is affected by high levels of urbanisation and, given that sixteen of the twenty most populated output areas (as seen in Figure 4.4) in the study area occur within this five kilometre radius of the city centre, it would appear that more densely populated areas are associated with OSEI. Mean population density in areas with instances of OSEI was higher than the sample mean, although the difference proved not to be statistically significant for the study area as a whole (Section 4.2.2).

As stated in the Section 1.2 of this thesis, early modern examples of social-ecological activism began in and around the city centre of Manchester and the current distribution of such activities may also follow this historical trend. Urban centres are widely acknowledged as being hubs of social, technological and cultural innovation (Dvir and Pasher, 2004; Grove, 2009; Ernstson et al., 2010; Leichenko, 2011; Glaeser, 2011) It is perhaps not a surprise, therefore, that examples of organised social-ecological innovation are more commonly found close to the centre of urbanisation of the study area. City centres and their immediate surroundings form the nexus of social interactions due, in no small part, to the simple fact that such areas are highly populated and as such provide opportunities for social networking, exchanging of ideas and collaborative creativity. The results of the mapping exercise certainly do not refute this trend and support the argument that highly populated urban areas are those most likely to produce innovation generally, including that of a social-ecological nature. The results of the analysis in Section 4.2.2 therefore address, in part, research objective 1, detailing the geographical distribution throughout the three districts

comprising the study area and indicate that proximity to the central urban district had an influential effect on the occurrence of organised social-ecological innovation.

## **ii) Cultural characteristics**

The analysis of population by ethnic group presented in Figure 4.5 demonstrated that areas where examples of organised social-ecological innovation were found tended to be home to a more culturally diverse population with figures for all ethnic groups proving to be statistically significantly higher than those areas where OSEIs were not recorded. This suggests a possible link between cultural and ecological capital in the social-ecological fabric of the study area, giving weight to such ideas as have already been posited by the United Nations Environment Programme (2002) as well as the more recent work of Galluzzi et al. (2010), Santilli (2012) and Barthel et al. (2013). This link was demonstrated quantifiably by the logistic regression analysis in section 4.2.2 which revealed that for every 100 persons population increase not belonging to the majority White-British ethnicity group in any given area there was an 11% increase in the likelihood of instances of OSEI occurring. Therefore for comparable population increases, the presence of minority groups appeared to be associated with the emergence of social-ecological innovation more than that of the majority white British population. As examples of organised social-ecological innovation recorded in the study area were characterised as being community-led and managed endeavours, the data point towards an association between cultural diversity and social-ecological capital.

As well as cultural conditions playing a significant role in the context of OSEI, there existed, as described in the introduction to this thesis, a historical blueprint of environmental activism in the study area landscape. Particularly areas such as Hulme (M15) and Ancoats (M4) were historically important in terms of the promotion of issues and education around environmental sustainability (see Chapter 1). LSOAs which corresponded to the areas covered by both these post code districts contained multiple OSEIs (21 in total, Appendix 1). Hence, almost 20% of OSEIs recorded in the study area were found occurring in close proximity to these historical “hubs” of environmental action (Section 4.2.2). This suggests that historical background and the resulting social-ecological network and memory which become embedded in the landscape over time, may constitute a significant mediating factor of OSEI occurrence in combination with other factors.

### iii) Land use characteristics

An initial visual appraisal of the distribution of sites of social-ecological innovation through mapping of NDVI data seemed to suggest that sites were not necessarily in or close to areas with plentiful vegetation (Figure 4.6); places where, it might be expected, there would be greater opportunity for ecological activities. Analysis of surface sealing by lower super output area revealed that instances of OSEI did in fact occur in those areas within the study region which were subject to greater extent of surface sealing with a highly significant ( $p = 0.002$ ) mean difference to the rest of the study area (Figure 4.7). A large proportion of surface sealing (32%) was due to cover by buildings, for which areas did not, however, demonstrate significantly different mean values.

As well as, and perhaps as a consequence of, high levels of surface sealing, areas which were home to OSEIs also contained a statistically smaller area of land cover by domestic gardens than the rest of the study area. In fact, domestic garden cover was the physical characteristic across which OSEI localities differed from the remainder of the study area with the highest level of statistical significance (at the  $p < 0.001$  level, Figure 4.10). Amount of public green space in a particular area appeared to have no significant bearing on the likelihood of OSEI occurring, although proportion of total green space cover was revealed to be highly statistically significant (Section 4.2.5). The results therefore lead to the assertion that physical factors in the landscape are a significant predictor of the occurrence of OSEI. Generally speaking, areas which contain higher levels of surface sealing proportional to green spaces are more likely to contain examples of OSEI with the absence of domestic gardens appearing to be a primary factor in initiating the emergence (Figure 4.10). Loss of quality green space is a usual casualty in the wake of urbanisation (Stein et al., 2000; UK NEA, 2011) and the need for multi-functional natural spaces may cause communities to mobilise towards achieving such goals, via the self-management of communal spaces, in order to maximise utility. Clearly, where allocation of private gardens is also sparse this exacerbates the problem and one logical solution seems to be for residents to pool resources and create communally accessible amenity spaces to alleviate the pressures of living in highly built-up environments.

#### **iv) Socio-economic characteristics**

The relative lack of provision of green space in areas containing OSEI was echoed in the socio-economic data analysed in the mapping exercise. Social-ecological innovation was more prominent in areas that were on average more highly deprived (IMD score: mean = 39) than the rest of the study area (mean = 33;  $p = 0.006$ ) and well above the UK average of 22 (Figure 4.13). The trend was equally supported by adding Experian MOSAIC group data to the analysis. Areas with and without evidence of OSEI differed significantly across MOSAIC group data (Section 4.2.4, Figure 4.11). This was characterised by a high percentage of OSEI locations (20%) as being most populated by households falling into the category “Welfare Borderline” with very few areas (< 5%) typically represented by more affluent groups such as “Symbols of Success”, “Happy Families” and “Suburban Comfort” (Figure 4.12).

#### **4.3.4 Types of organised social-ecological innovation in the urban landscape**

The exploration of distribution of OSEIs according to type of OSEI in Section 4.2.6 revealed that the localities of discrete types of social-ecological innovation showed significant variation across the demographic (population density), ecological (land-cover) and socio-economic (deprivation) contexts in the assessment. Again, as in the case of occurrence of OSEIs overall, (described in sections 4.2.2 to 4.2.5) all three categories of analysis of the urban landscape proved to be significant in terms of their influence on the spatial distribution of the diverse types of OSEI recorded.

Based on the attributes examined it was possible to characterise the localities of the five types of OSEI relative to each other as follows:

#### **i) Community gardens**

The locations of community gardens were characterised principally by above mean levels of population density (Figure 4.16), and socio-economic deprivation (Section 4.2.6) with a low mean proportion of sealed surface cover relative to other type locations (Figure 4.15: 45%, including high density of domestic gardens). As such, these localities can be described as

areas with high availability of green space coupled with equally high levels of social deprivation and population density relative to the localities of the other four types of OSEI recorded.

**ii) Community allotments**

Similar to community garden localities, community allotments occurred in areas with a below mean proportion of surface sealing relative to other types (the lowest overall at 38%, Figure 4.15), and levels of deprivation close to the OSEI grand mean IMD score (39.46) at 38.38 (Section 4.2.6). Mean population density was lowest in community allotment localities (Section 4.2.6).

**iii) Pocket parks**

Pocket parks occurred in areas with lower levels of overall deprivation than all other types with the exception of community orchards (Section 4.2.6). However, such areas exhibited the highest mean level of crime and disorder according to Index of Multiple Deprivation data (Figure 4.18). Conversely of all OSEI locations, proportion of sealed surface was highest on average for pocket parks with a mean percentage cover of 71%, a value 40% higher than the OSEI grand mean (Figure 4.15).

**iv) Community orchards**

Community orchards occurred, on the whole, in areas with the lowest levels of socio-economic deprivation in the sample and with sealed surface cover below the mean for OSEI localities at 46% (Figure 4.15).

**v) Environmental resource projects**

Of all the types of OSEI identified in the mapping exercise, environmental resource projects were those which occurred in areas with highest combined level of social and ecological deprivation (Figure 4.19).

The position of OSEI types in the evaluation of combined social and ecological deprivation in Figure 4.19 demonstrated that community allotments and community orchards occupied areas of moderate levels of deprivation across both measures, whereas pocket parks and community gardens, as the other provisioning OSEI types in the study, occupied areas which veered towards extremes of either ecological or social deprivation, respectively.

Environmental resource projects were found in areas which exhibited relatively high degrees of both social and ecological deprivation, above the type sample mean for both measures (Section 4.2.6). Conversely, community orchards displayed equal measures of mean social and ecological deprivation though with more moderate values for each (Figure 4.19).

Of the demographic, ecological and socio-economic parameters analysed, and again, as in the case for OSEI distribution overall, the ecological context (surface sealing) of a given area appeared to be the most significant ( $p < 0.001$ ) in determining the type of OSEI likely to occur as demonstrated in the analysis of variance in section 4.2.6. A detailed analysis of the contributory elements of which each factor was comprised, through the discriminant function analysis described in Section 4.2.6 (Table 4.10), added satisfactory confirmation of the saliency of ecological elements in the landscape on the emergence of types of OSEI.

Notwithstanding these insights gained on the relative impact of the levels of both social and ecological deprivation which influenced the distribution of OSEI type in the study area, there existed also a complex dynamic between the two. The representation of the data in Figure 4.19 served to illustrate that particular configurations of combined social and ecological deprivation more readily encouraged the presence of particular types of OSEI. At the moderate level of social-ecological deprivation (bottom-left of Fig. 4.19), areas in which deprivation was more specifically ecological rather than social were more likely to provide conditions for the creation of community orchards, whereas in areas where social deprivation was the more salient characteristic, community allotments were the type of OSEI most likely to be found. At the extremes of social-ecological deprivation, environmental resource projects were more commonly found in areas of high social deprivation whereas locations subject to extreme ecological deprivation (i.e. surface sealing) were more likely to engender pocket parks as a form of OSEI (Fig. 4.19). Importantly, community gardens and pocket parks, although occurring in areas at the limits of social and ecological deprivation respectively (Figure 4.19) exhibited much lower mean levels of deprivation for the other component factor. That is to say that community gardens appeared in areas which were among those most highly socially deprived in the study area but which exhibited levels of ecological deprivation below the sample mean for OSEI locations. Likewise, pocket parks occurred in areas which presented the inverse of this dynamic.

The locations which exhibited the greatest degree of equal levels of social *and* ecological deprivation were those in which environmental resource projects were found occurring



(Figure 4.20). Being that such OSEIs were primarily examples of *supporting* as opposed to *provisioning* forms of OSEI, it could be inferred that beyond a certain level of combined social *and* ecological deprivation, provisioning OSEI is less likely to occur and a supporting version of the phenomenon is more commonly found. Furthermore, as exemplified in the observed dynamic between the social and ecological contexts of community gardens and pocket parks previously highlighted, it would seem that provisioning forms of OSEI can occur in areas subject to the highest levels of social or ecological deprivation providing that such deprivation is buffered to a certain degree by more favourable conditions in the other parameter. In this way, the analysis in this chapter uncovered the seeming existence of a dynamic arrangement of thresholds which shape the social-ecological contexts, boundaries and tipping points nested in the distribution of organised social-ecological innovation.

#### **4.4 Conclusions of the mapping exercise**

The results and subsequent analysis presented in this chapter provide strong evidence that ecological, socio-economic as well as demographic factors, in the urban landscape, all play a significant role in the emergence and distribution of organised social-ecological innovation observed in the study area. In terms of content, urban agriculture was a primary expression of OSEI recorded and was prevalent across all types (Section 4.2.1).

##### **4.4.1 The urban context of organised social-ecological innovation**

The clearest pattern in terms of the spatial distribution of OSEIs was described in terms of the proximity of sites to the urban “hub” of the study area, that being the central commercial district of the city of Manchester. Further to this, a highly clustered distribution revealed by the nearest neighbour analysis in Section 4.2.2 suggests the OSEI occurrence may be shaped to some degree by the presence of social-ecological networks. Further research would be necessary to evaluate the relative importance of such networks on the facilitation of social-ecological innovation. Specifically, the greater incidence (69%) of OSEIs occurred no more than 5km from the city centre (Figure 4.3), suggesting that these kinds of inner-city spaces may be hotspots of innovation generally and, under certain environmental and socio-economic conditions, innovation of a social-ecological nature. Given that proximity

to the city centre is generally associated with lower levels of green space, the effect is likely to be maximised in these areas with the relative effect of each difficult to delineate.

Those conditions mentioned above can be described, according to the analysis performed in this chapter, as consistently demonstrating elements of both ecological and socio-economic deprivation. Areas (LSOAs) which contained a percentage cover of green space below 50%, (Section 4.2.5) as well as levels of deprivation equating to an IMD score of 39 or over (Figure 4.13), are likely to provide the social-ecological conditions which result in the drive amongst communities to mobilise towards some form of organised social-ecological innovation.

Particularly, areas which contain low levels of domestic garden cover (Figure 4.10), high levels of crime and health deprivation (Table 4.3), and high cultural diversity (Figure 4.5), and capital (Figure 4.12), were most likely to provide the impetus for the occurrence of OSEI.

#### **4.4.2 Urban fabric complexity and adaptability in organised social-ecological innovation**

Of note was the contrast in localities of community gardens and pocket parks, the former occurring chiefly in greener areas with high levels of overall deprivation. In contrast, the latter were recorded in areas which exhibited the inverse of these characteristics (Section 4.2.6). A further layer of contrast between the two types was provided by the fact that community garden localities, despite high levels of overall deprivation, enjoyed mean levels of crime and disorder below the sample mean whereas pocket park localities, again presented the inverse of this situation: low IMD score despite highest mean levels of crime and disorder for all types (Figure 4.18).

Of the two types, community gardens are a more established form of OSEI (see section 2.9), occurring with the greatest frequency across the study area whereas pocket parks demonstrated the most highly improvised, innovative and, as such, the most recent approach to OSEI within the typology and with comparatively lower frequency (see Table 3.2). Given the prominence and relatively longer legacy of community gardens in the urban environment and the tendency for them to occur in highly deprived areas, it may be that such examples of OSEI provide a particular benefit to those areas in terms of social capital and cohesion (as asserted by the studies cited in sections 2.11 of this thesis). Consequently such improvements may lead to reduced rates of crime and disorder, buffering communities against otherwise high levels of socio-economic deprivation. Similarly, the perceived benefits

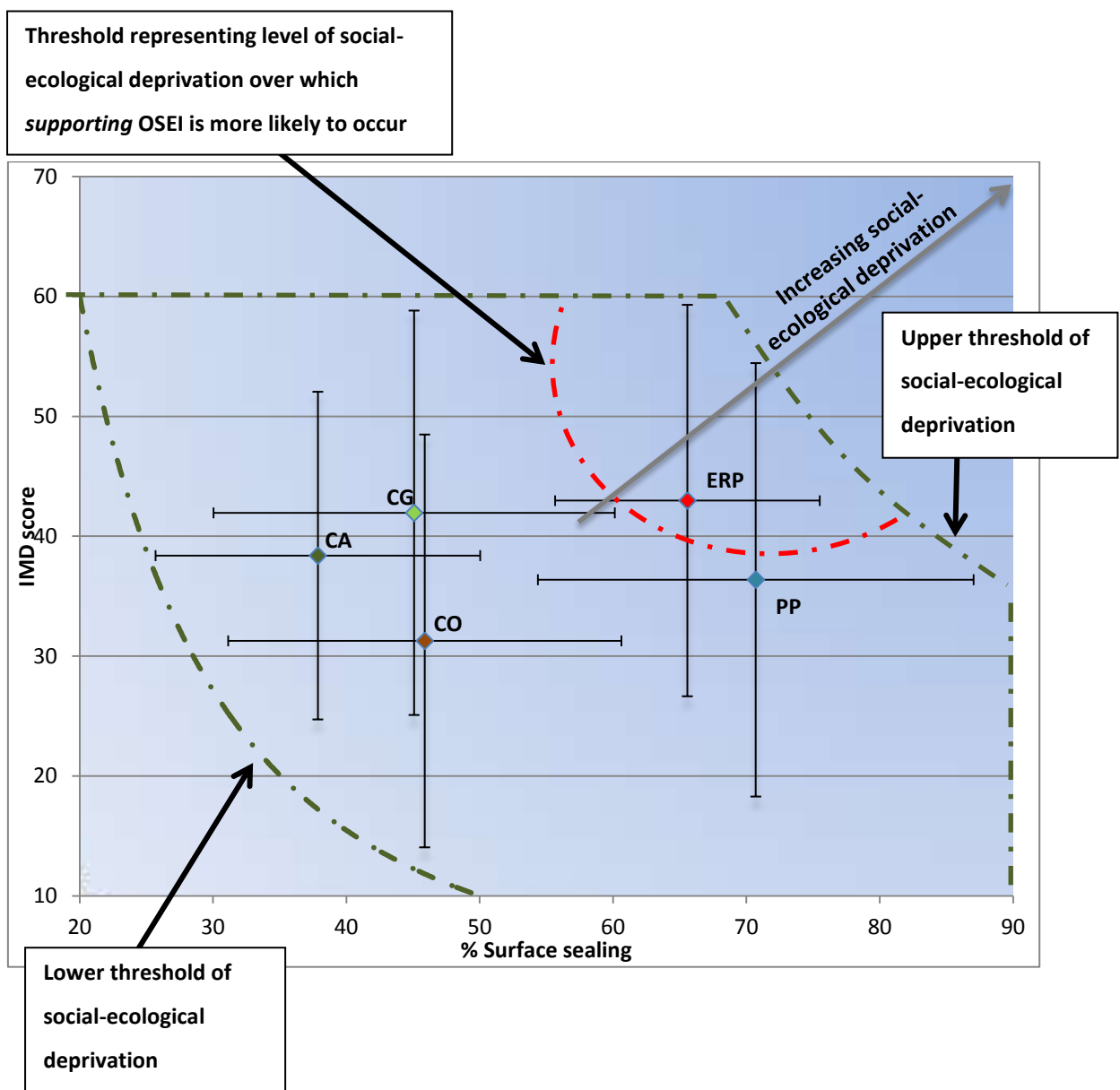
of OSEI in terms of community cohesion may be one reason why certain, otherwise affluent, areas (primarily highly urban, central locations) are now looking to such innovation as a means of alleviating unwelcome levels of crime and disorder associated with city centre living. Given the lack of available green space in these areas, the most common expression of such innovation in central locations took the form of pocket parks (Figure 4.20). The contrast in OSEIs and their localities observed in the mapping exercise demonstrate the multi-faceted nature of the social-ecological benefits which can be derived from OSEIs and the adaptive capacity of OSEI in meeting the needs of communities in different social-ecological contexts.

#### **4.4.3 Social-ecological networks: distribution and thresholds in organised social-ecological Innovation**

Being that urban areas are, ecologically speaking, highly modified by human activity, they, in essence, necessarily consist of complex social-ecological networks (Ignatieva et al., 2011). The distribution of OSEI throughout the study area comprised one of the nested elements in a broader social-ecological system. The role of semi-formal social-ecological innovation in the wider urban fabric, particularly their potential importance in terms of urban resilience, is a consideration which, although alluded to in the literature (Dietz, 2003; Cash et al., 2006; Bodin and Crona, 2009; Barthel et al., 2010; Colding et al., 2013), has not as yet been delineated in terms of the spatial dimension of its nascence and the social-ecological thresholds which shape its expression in the landscape. The analysis presented in this chapter brings focus to these issues, illustrating the distribution and context of OSEI and the various forms which it takes. Specifically, the analysis in the previous sections of this chapter provided a novel appreciation of the physical distribution of OSEIs in the urban landscape and those social-ecological conditions, marked by the interaction of significant levels of deprivation, which were associated with specific approaches to OSEI.

The appearance of OSEI as a general phenomenon as well as the distribution of the five discrete types of OSEI found in the mapping study were conditioned by social-ecological factors, the influence of which involved the presence of particular thresholds. The occurrence of OSEI seemed to be triggered by comparatively high levels of social-ecological deprivation, relative to the study area as a whole (Section 4.2.5). Therefore, a minimum of social-ecological deprivation, as a lower threshold, appeared to be necessary to provide the

impetus for the production of OSEI. This stimulus for the emergence of OSEI continued through increasing levels of social-ecological deprivation, with different configurations of social and ecological conditions resulting in discrete types of OSEI until an upper threshold of deprivation was reached (Figure 4.19). Severe levels of local deprivation beyond this threshold subsequently appeared to inhibit the occurrence of the phenomenon (Section 4.2.7). Interestingly, the relationship was not linear and, furthermore, at both the upper and lower limits of social-ecological deprivation, the thresholds which described the range of social-ecological conditions likely to produce instances of OSEI, were sensitive to the tension between respective social and ecological factors. Figure 4.19 demonstrated that, at the lower threshold, a certain degree of deprivation increased the likelihood of OSEI occurring. However, the same figure revealed that, when relatively high levels of ecological deprivation in a given area were buffered by more favourable social conditions, and vice-versa, then OSEI appeared less likely to occur. Therefore, relatively lower levels of social and ecological deprivation, when found co-occurring, were more likely to provide a context for OSEI. This effect was mirrored at the upper threshold of social-ecological deprivation (Figure 4.19), where, once particular combined levels were reached, the occurrence of OSEI appeared to be significantly hindered. Again, as seen at the lower limits of deprivation, the buffering of high levels in one factor by relatively lower levels in the other affected the limits of this threshold. Here, relatively lower but equal degrees of combined social and ecological deprivation had a more deleterious effect on the emergence of OSEI than did a situation where higher levels of deprivation in either social or ecological conditions were mitigated by low levels in the other component factor. This tendency is summarised in Figure 4.22, which is an annotated version of the scatter plot of mean social-ecological deprivation of type locations presented in Figure 4.19. Lower and upper thresholds are implied in the chart in Figure 4.22 based on type mean values and standard deviations across the two variables. A third threshold of combined social and ecological deprivation, above which *supporting* versions of OSEI appeared more common, suggested in the data analysis in Section 4.2.7, is also included.



Key: CG = community garden; CA = community allotment; PP = pocket park;

CO = community orchard; ERP = environmental research project

**Figure 4.22 Thresholds in the occurrence of OSEI.**

The comparative influence of social-ecological conditions on OSEI type occurrence and on OSEI distribution in general, as outlined in Figure 4.19, goes some way to explain the apparent “gaps” in the landscape visible in Figure 4.21 where areas marked as suffering from upper extremes of social-ecological deprivation did not exhibit evidence of OSEI. In such cases, areas suffering from extremes in both social and ecological poverty find themselves beyond the upper threshold of conditions which would encourage the occurrence of OSEI.

As illustrated in Figure 4.21, many of these “gaps” are situated to the east of the urban centre. Such areas were also subject to some of the highest IMD scores in the study area (Figure 4.13). Although poor ecological conditions proved to have the most significant influence overall on both the emergence of OSEI and OSEI type in a particular area (Sections 4.2.1-4.2.7), it could be inferred that, at high extremes of social-ecological deprivation, socio-economic conditions become pivotal in ensuring the potential for OSEI. High levels of social deprivation, leading to weaker ties in the community and less extensive social networks (Poortinga, 2012) may decimate the opportunities for OSEI to flourish. This inference is backed up by the fact that the localities of pocket parks, despite being the most ecologically deprived in the study, were still fertile ground for innovation by virtue of enjoying relatively superior socio-economic conditions. The salience of healthy social networks as a facilitating factor in OSEI is further underlined by the analysis of deprivation in community garden localities. Such areas exhibited the second highest mean level of social deprivation of OSEI types but the relatively much lower IMD domain score for crime and disorder (Figure 4.18) pointed to a strong degree of social cohesion (Afridi, 2007) which may be critical in the appearance of OSEI. Although OSEI was defined as a semi-formal approach to ecosystem management, there clearly was a degree of community mobility required in order for it to become established and, particularly at the upper limits of social-ecological deprivation, the existence of a minimum (and improving: Figure 4.14) level of socio-economic capital should lend itself to the success of this *organised* phenomenon. That community gardens comprised the most established expression of OSEI in the study area (35% of the total, Table 4.2), and that areas containing community gardens exhibited high mean IMD scores but with comparatively lower domain scores for crime and disorder deprivation (Section 4.2.6; Figures 4.17 and 4.18), points to the potential benefits in terms of social capital from the presence of OSEI. This would support claims in the literature that community gardening as a form of social provisioning reaps significant gains in terms of community cohesion (Armstrong, 2000; Hancock, 2001; Wakefield et al., 2007; Kingsley et al., 2009; Teig et al., 2009). It must be stated that these inferences are derived from quantitative analyses and, as such, are preliminary and would benefit from confirmation as to their validity by a more qualitative investigation of social-network analysis and community cohesion. Notwithstanding the shortcomings of a purely quantitative analysis, the data describe organised social-ecological innovation as a significant presence in the urban landscape, the

impetus for which appeared to be principally related to increasing degrees of ecological deprivation, resulting from high surface sealing and a lack of availability of domestic green space in particular, combined with above average levels of social deprivation. However, the emergence of OSEI in such locations was subsequently modified by social conditions where social cohesion played an important yoking role and where, alternatively, particularly extreme levels of socially-oriented deprivation acted to hinder the potential for OSEI. Within this overall social-ecological dynamic there existed various nuances which revealed further complexity in the social-ecological system. One such nuance was exemplified by the fact that, compared to the rest of the study area, the localities of OSEIs appeared to be improving, in terms of measures of multiple deprivation, at a much greater rate (Figure 4.14) whereas LSOAs which exhibited worsening conditions over recent years were largely lacking instances of OSEI. This suggested an association between the emergence of OSEI and improving socio-economic conditions, that is, between increasing social mobility in historically deprived areas and local ecosystem management. The direction of this relationship would, however, require further research to be fully understood.

Also, there was clearly a level of complexity within socio-economic parameters which drove the production of OSEI in certain areas. Particularly in the case of community garden locations, although poor socio-economic conditions prevailed, OSEI was nevertheless produced, likely as a result of the buffering effect of relatively strong levels of social cohesion as inferred by the anomalously low levels of crime and disorder deprivation in such areas (Figure 4.18). At the upper extremes of social-ecological deprivation in the study area, where OSEI was seemingly no longer tenable, areas differed most significantly from those containing OSEIs across the social deprivation parameter (IMD score, Section 4.2.7).

Therefore, although ecological factors were the more prominent in determining the conditions likely to drive and shape social-ecological innovation, changes in socio-economic conditions were pivotal in defining the upper limits of social-ecological deprivation at which OSEI arise.

The modifying effect of social networks and cohesion on poverty and health deprivation, as a form of social capital, has been previously documented (Fone et al., 2007). However, that *ecological* capital, through informal local urban ecosystem management, is one of the results of such social capital has been, as yet, largely unexplored in the relevant literature.

Community garden locales, given that green space density was above the mean value for

OSEIs, also provided examples of situations where poor socio-economic conditions, as well as potentially leading to community breakdown, can also trigger beneficial social action (Cattell, 2001). A further layer of socio-cultural complexity was provided by the fact that ethnic group composition was significantly more diverse in areas where OSEI was found (Figure 4.5; Section 4.2.2) suggesting that cultural diversity also played a modifying role in creating the conditions conducive to OSEI.

#### **4.4.4 OSEI as an adaptive response to local social-ecological conditions**

The occurrence of OSEI in the landscape and pattern of distribution in OSEIs can be explained through the adaptive cycle framework whereby OSEI is clearly an adaptive response to the breakdown of previously over exploited ecological and socio-economic parameters in the study area. Ecologically speaking, unmitigated levels of land sequestration for housing, infrastructure and other urban amenities deleteriously affects urban quality of life and resulted in an absence of opportunities for human-nature interaction. Such a decline has been characterised by reduced funding for public parks, lack of park services and the sale of recreational land and allotments (UK NEA, 2011). This scenario resembles closely the culmination of the *K* (conservation) phase of the adaptive cycle whereby, after a long period of capacity and efficient managing of abundant resources (i.e. urban land/green space), the effects of such trends cascade down and areas fall into ecological decline with knock on effects for human and environmental health and well-being at local scales ( $\Omega$ /release phase). This trend is mirrored by socio-economic factors with the regional and global over-exploitation of both economic and environmental systems leading to global recession. Such a collapse again resembles transition from a mature *K* phase of the adaptive cycle into the  $\Omega$  phase, experienced, at the local level, through economic hardship and, in particular, food poverty (Wrigley, 2002; Wrigley et al., 2003; Dowler and O'Connor, 2012). The North West region has the greatest average number of people using food banks in the UK (Centre for Local Economic Strategies, 2012). Furthermore, according to the Greater Manchester Poverty Commission revealed that 15% of people in Greater Manchester skip meals due to economic hardship (Manchester Food Poverty, 2015) with the city of Manchester containing the highest number of food banks in the Greater Manchester area (Centre for Local Economic Strategies, 2012). Given that the vast majority of OSEIs occurred in the Manchester district (Figure 4.2) this supports a view of OSEI as an adaptive response



influenced by food poverty. The emergence of OSEI thereby resembles an adaptive response to a combination of local levels of social and ecological deprivation. Such a response would fit the intermediate “innovation” stage during the “back-loop” from the  $\Omega$  to the  $\alpha$  phase of the cycle (see Figure 2.2). Given that the form of such innovation in the vast majority of cases focusses on food and urban agriculture, it is likely that “remembered” (see Figure 2.3) adaptive capacity from the wider pre-existing social-ecological system is facilitating this movement. Specifically, in the case of OSEI such social-ecological may come in the form of local horticultural knowledge and urban agricultural know-how, transmitted by, for example, a heritage of allotment gardening (Barthel et al., 2010; 2013; 2014) and supported by historical hubs of social-ecological innovation (Section 4.2.2). Further qualitative research into the motives and practices of actors involved in OSEIs would help to further substantiate such inferences. The social characteristics of the study area as obtained through the analysis of Experian Mosaic data in Section 4.2.4 would appear to fit the model also. LSOAs where OSEI was recorded were differentiated from areas where it was not by a large proportion of neighbourhoods belonging to Mosaic categories five and six: Urban Intelligence and Welfare Borderline. As such the locations of OSEIs consisted of highly deprived areas but which contained a large proportion of neighbourhoods being home to younger, educated people living in relatively cheap housing in inner city areas. Such residents therefore represent an element of social-ecological capital in the landscape and a degree of social mobility. This may be necessary to create connections and generate innovation by harnessing the pre-existing social-ecological memory within the system and exploiting forgotten, abandoned or under-used resources (or the creation of new ones) which appear during the  $\alpha$  phase when re-organisation occurs. Areas above the critical percentile rank of 0.91 (see Table 4.12) contained considerably fewer residents belonging to the “Urban Intelligence” (Section 4.2.7) group which may be a reason why such areas represented social-ecological blackspots, or “poverty traps” whereby the necessary social capital is not sufficiently abundant to effectively set possible innovations in motion in order to move locations into a new phase of adaptive resource management. The fact that areas containing OSEIs were on the whole more socially deprived than the remainder of the study area but that they were also improving at a greater rate (Figure 4.14) adds credence to this interpretation. That such areas have clearly been the subject of significant historical declines in socio-economic (and ecological) conditions sets the scene and gives the impetus for the emergence of innovation

and re-organisation with the subsequent improving levels of socio-economic capital (as denoted by decreasing IMD score) providing the medium for new effective approaches to local resource management and transition into the *r* stage.

Importantly, of all deprivation domains analysed, education did not appear to be a casualty amongst the high levels of deprivation seen at OSEI locations. This provides further weight to this factor being an essential form of social-ecological capital providing impetus for new niches in approaches to local ecosystem management. The creation and filling of niches is another key aspect in the *r* phase of the adaptive cycle. In terms of the emergence of OSEI, such niches are filled according (principally) to ecological constraints and are done so generally by the appearance of different types of OSEI (see Section 4.2.6) and, specifically, by site design which adapts to site conditions and the requirements of community members. Subsequently, social-ecological capital would continue to grow into the *K* phase.

The presence of “traps” in the cycle can also be identified in the exploration of OSEI in the study area. The intensive conversion of green space for infrastructure and the almost complete reliance on the importing of external goods and resources resembles a kind of “rigidity trap” whereby existing self-reinforcing levels of exploitation have created a steady but inflexible management style (“stuck in the *K* stage”). Over time, internal fluctuations such as increasing food poverty, crime and disorder or health deprivation eventually drag a system or parts thereof into a phase of creative destruction ( $\Omega$  phase) where new social and ecological configurations are allowed to coalesce (Carpenter and Brock, 2008). Similarly, where, following such a transition, the necessary social-ecological memory, knowledge or mobility is lacking, local areas may become stuck in “poverty traps”. Such an occurrence is exemplified by the presence of social-ecological “blackspots” in the study area (highlighted in Figure 4.20). The fact that OSEI seemed to occur in areas which were on the whole more culturally diverse (Figure 4.5) may also add to the social-ecological resilience in the landscape as contributing to a wider knowledge of a variety of crop types and cultivation techniques, as suggested, for example, in Barthel (2013).

#### **4.4.5 Defining networks in social-ecological innovation**

From the distribution, social-ecological configurations and typology of OSEI evaluated, it was possible to outline the existence of an informal social-ecological network underpinning the expression of OSEI in the landscape. The central urban district, demarked by the city centre

of Manchester provided the principal geographic focus for the distribution of OSEIs with the majority occurring within the “inner-city” region described by the 5km buffer presented in Figure 4.3. This highly urban area contained examples of all forms of OSEI included in the typology and, in particular, all recorded examples of pocket parks and environmental resources projects. This latter form of innovation, occurring in areas of highest combined social and ecological deprivation (Figure 4.20), consisted of a supporting network of OSEIs. Housed in premises in primarily central locations, such sites acted as hubs in both the physical landscape (being found in close proximity to other OSEIs) and the social landscape, often hosting two or more groups of actors and providing venues for environmental forums and workshops.

As such, these environmental resource *centres* provided a cross-scale supporting mechanism network of OSEIs in the study area. Other, primarily provisioning forms of, usually well established, OSEI also fulfilled a similar supporting function at the local scale through the organisation of community events and training workshops (see case-study in Chapter 5). As discussed in Section 4.2.2, a high percentage of OSEIs occurred in historical hubs of OSEI and, of these, the majority fell into the category: environmental resource project (see Appendix 1). This suggested that such areas demonstrated a sustained operational presence in the social-ecological landscape which functioned through the activities of this particular form of OSEI. In terms of the environmental conditions which encouraged the development and spread of OSEI, areas subject to those levels of social-ecological deprivation within the lower and upper thresholds described in Figure 4.22 effectively comprised “hot-spots” for the emergence of OSEI. Levels of deprivation below the lower threshold did not readily provide the impetus for OSEI and areas beyond the upper threshold in Figure 4.22 consisted of social-ecological “black-spots” in which levels of social *and* ecological deprivation were so high that social-ecological mobility appeared to breakdown and OSEI became uncommon. The physical dimension of individual examples of OSEI also exhibited considerable variation. As described previously, environmental resource projects often housed or hosted multiple environmental initiatives as in the case of the Manchester Environmental Resource Centre initiative (MERCi). The inverse of this format was also observed where a particular social-ecological initiative took the form of a small coherent network of sites (primarily pocket parks) such as the multi-locational city centre project “Northern Quarter Greening”. Taking into account the specific social and ecological parameters which shaped the distribution of

sites recorded in the study, it was possible to discern the presence of a coherent social-ecological network nested in the study area landscape of which organised social-ecological innovation was a primary expression. A template for such a network is theorised in Figure 4.23 with examples of OSEIs recorded in the study area.

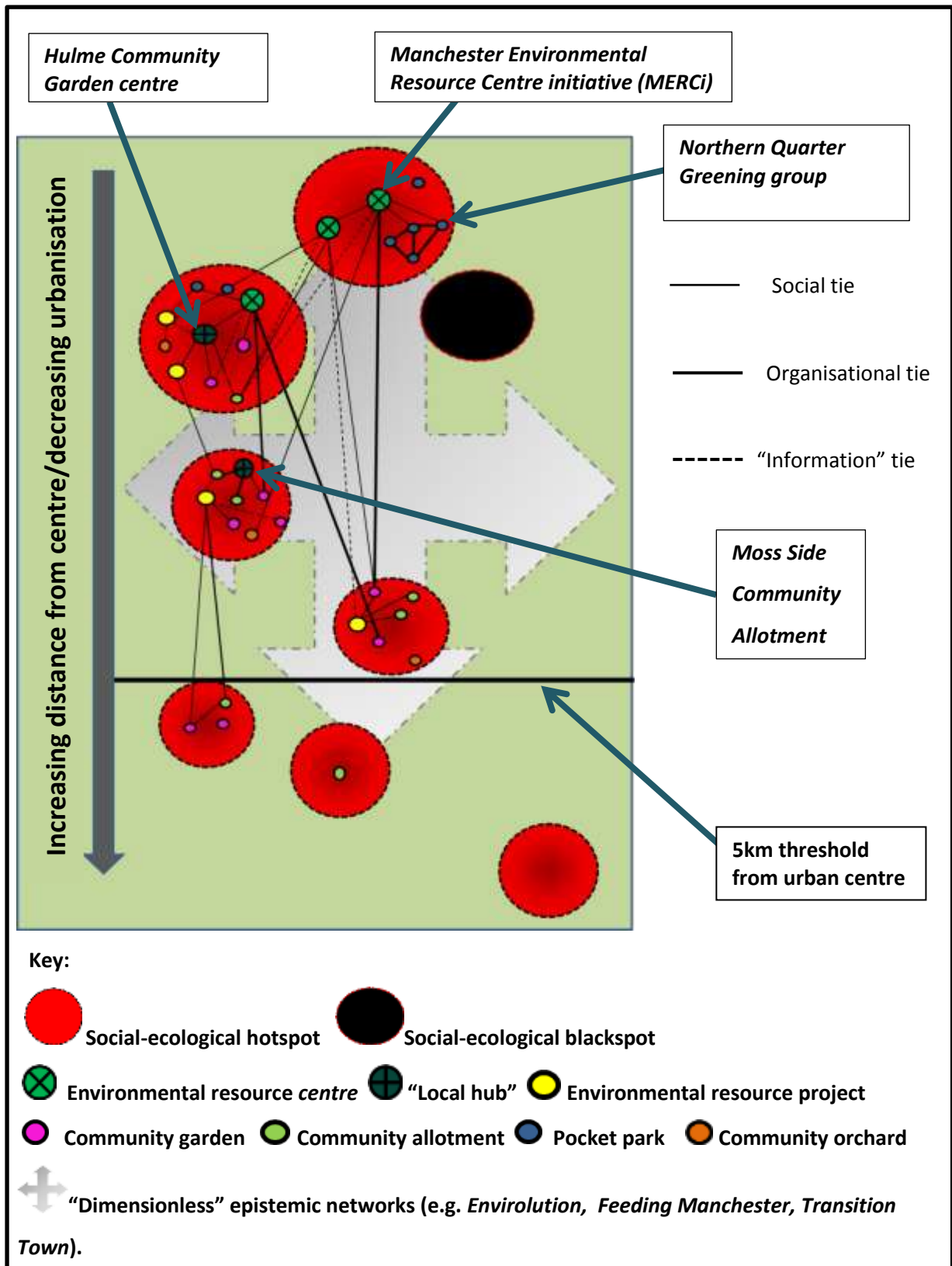


Figure 4.23 Suggested model of social-ecological networks associated with OSEI.

The network outlined in Figure 4.23 describes the main characteristics of OSEI distribution. In terms of spatial distribution, the highest density of OSEIs occurred in and around the central urban area (Manchester city centre) which exhibited the highest degree of overall social-ecological deprivation and, in this sense, the principal social-ecological “hotspot” for the potential emergence of OSEI. Pocket parks typified the approach to OSEI in the most central area where deprivation was marked by very high levels of surface sealing. The transitional zone between central and “inner city” areas on the outskirts of the central business district were host to community gardens, in areas marked by relatively lesser ecological deprivation and by environmental resource projects where surface sealing and social deprivation were both equally severe. This zone in the urban geography also contained the majority of the social-ecological black-spots, consisting primarily of severely socially disadvantaged areas. Such conditions prevented the necessary minimum of social capital which appeared vital in order to expedite OSEI development. With increasing distance from the centre of urbanisation, pocket parks and environmental resource projects were less common and no examples of either type were found more than 5km from the urban centre. With increasing distance from the urban centre, social and ecological conditions generally improved and outside the 5km buffer zone of greatest social-ecological deprivation the OSEI types community allotment and community orchard were more common.

Community gardens were unique in terms of the geographic extent and range of social-ecological conditions in which they occurred. Although the majority fell within a 5km radius of the central urban point, their distribution continued to the outer geographic limits of the study area. In social-ecological hotspots found occurring in the suburban and peri-urban regions of the study area, which exhibited more moderate levels of deprivation, community-led allotments and orchards were a common feature, the latter occurring in the least socially deprived areas on average of all OSEI types (Figure 4.19).

The physical network of sites is modified by local and cross scale supporting networks. This is characterised by a number of formal and informal organisational actors. Formal support involving promotion, skills sharing and networking is provided by environmental resource *centres* and their tenants as well as certain “dimensionless” epistemic elements involved in environment-based educational provision (see Section 4.2.1). A complementary, less formal

network of support was achieved through local community events, educational visits and workshops (see case-study analysis, Chapter 5) at prominent, well-established examples of provisioning OSEIs. Ties in the network presented in Figure 4.23 are also suggested.

Organisational ties describe situations where OSEIs are under the direct supervision or management by larger umbrella groups which are typically environmental resource projects. Such ties also describe multi-locational projects where physically discrete sites are part of a wider whole as in the case of the “Northern Quarter Greening” project or the “Incredible Edible Salford” group (Incredible Edible Salford, 2014). “Social” ties describe informal collaboration or sharing of knowledge and/or resources and “information” ties denote sharing of ideas which may take place through forums and events or at distance, via correspondence or information made available on the internet. A full understanding of the nature of the explicitly social network underpinning the development of OSEI would require further concerted research.

The distribution of social-ecological deprivation in Figure 4.21 also illustrates gaps in the landscape which would constitute social-ecological hotspots given the established characteristics of OSEI localities but which showed no evidence of OSEI (as outlined in Section 4.2.7). The distribution of OSEIs in the map of social-ecological deprivation in Figure 4.21 also exhibits a lesser degree of clustering with increasing distance from the urban centre. At greater distances therefore, the occurrence of OSEI was more reliant on cross-scale supporting links as sites become more physically isolated. One result of this is that, in such outlying areas where the density of the physical network of OSEI is diminished, when hotspots of social-ecological deprivation do occur, OSEI is less likely to develop. The cause of this may be the absence of local supporting mechanisms and increasing distance from supporting organisations largely located at the urban centre. Such areas may subsequently become blackspots or “poverty traps” in the landscape, particularly if the social-ecological capital or access to social-ecological memory necessary to facilitate self-organisation and new approaches to management is lacking. It follows that the association of social-ecological innovation with increasing proximity to the urban centre means that urbanisation becomes a vital resource for social-ecological resilience. However, it also results in the high centrality of the social-ecological network itself which would tend to decrease the overall resilience of

the network in the process. Out-of-town, peri-urban areas may suffer from isolation in the long-term as a result.

The presence of supportive links in the social-ecological network was evident, a more detailed assessment of the structure of which may facilitate the integration of OSEI into an adaptive governance framework. However, without an evaluation of the actual productivity of OSEIs at the site-level, such adaptive capacity is unqualified. In order to address this knowledge gap, a case-study of 12 established OSEIs was conducted to assess a range of ecosystem services provided by the four types of *provisioning* OSEI as well as the dynamics and trade-offs found occurring in service provision. This evaluation is presented in Chapters 5 and 6.

## Chapter Five: Case-study of Sites of Organised Social-ecological Innovation

### 5.0 Introduction: case-study approach

The analysis presented in Chapter 4 demonstrated the extent and nature of the distribution of OSEIs in the study area landscape. Although, based on the available literature, it was possible to make inferences about the potential benefits of such social-ecological innovation, an appraisal of the delivery of specific urban-relevant ecosystem services by OSEI was undertaken by conducting a case-study analysis of service provision across twelve selected OSEIs covering the four *provisioning* types of OSEI described in Chapter 4.

The data collected in Chapter 4 were based on the presence, context and basic remit of types of OSEI. These data, although facilitating an evaluation of OSEI as a spatial phenomenon at the landscape scale, did not allow for a detailed understanding of the nature of OSEI as a *practice* animated by social-ecological inputs and outputs at the site level.

Certain theoretical perspectives, derived from the review of literature in Chapter 2, underpinned the investigation of ecosystem services provision derived from OSEI upon which the case study centred. These were: that food production was a prominent ingredient of OSEI, that there existed the potential for trade-offs and synergies between services derived from OSEI, that *types* of OSEI exhibited common service-related characteristics and that human (community) input served to mediate the productivity of OSEIs in terms ecosystem services (see aims and objectives, Section 2.13). Again, such perspectives were best explored by employing an in-depth, on-the-ground investigation from a case-study orientation (Yin, 2003). The lens through which this in-depth exploration into the case study sites was carried out was that of the ecosystem services framework, tailored to the physical and thematic context of the study. Site character, management and productivity was thereby analysed from the viewpoint of ecosystem service provision.

Section 5.1 describes the case study selection process after which case study sites are briefly introduced and Section 5.1.5 details the rationale for the selection of four key ecosystem services to be assessed. Data collection methods are set out with justifications in Section 5.2 and results of site surveys, observations and ecosystem services assessments are presented



in Section 5.3. An initial discussion employing basic statistical and descriptive analysis then follows in the final section of this chapter. Further analysis of ecosystem service valuation and evidence of trade-offs and synergies are documented in Chapter 6.

## **5.1 Case study site selection**

Following the initial mapping exercise, it was clear from the geographical and anecdotal information gathered, that sites to the south of Manchester city centre were those best established and for this reason it was logical to focus in this area when choosing sites for the purpose of studying ecosystem services associated with such activity.

In order to explore the effects of different types of innovation within the city, a comparison of sites associated with the four types of provisioning OSEI as established in the typology outlined in Section 4.2.1 was undertaken within the inner-city area presented in the Introduction to this thesis (see Fig 1. 2). Twelve sites (11% of the total population presented in Chapter 4) were selected as case studies from this area which allowed for three sites to be studied per category for the purpose of between type and within type comparison when looking at ecosystem service provision. In order to evaluate a range of ecosystem services derived from sites, case studies were chosen from well-established examples of OSEI in order to reasonably evaluate the potential productivity of the phenomenon. As such, case studies had to meet all of the Olsson and Galaz criteria detailed in section 2.12. OSEIs included in the general mapping exercise had only to exhibit evidence of one criteria as the purpose of this landscape-scale study was to explore the phenomenon as a coherent whole of which each instance of OSEI formed a part. However, an in depth study into individual cases of OSEI required that each site was well-established with an active membership, and met all the Olsson and Galaz criteria. It thereby followed that the analysis was, fundamentally speaking, comparing like with like, albeit across different types. Further, the selection criteria ensured that a full appreciation of the potential of OSEI in terms of ecosystem services was permitted by basing the evaluation on “model” versions of the phenomenon. The case study provided a snap-shot of site design, management and productivity and did not take into account change over time in this adaptive and ephemeral phenomenon. Those selected sites are presented below by type (geographic locations of case studies are subsequently presented in Figure 5.5).

### 5.1.1 Community gardens

#### 1. Centenary Gardens

This site was situated in the Old Trafford area and was created through a consultation between local residents and the local charity Groundwork Manchester, Salford, Stockport, Tameside and Trafford, transforming an area of derelict, under-used and neglected (DUN) land which had previously been occupied by a local Scouts centre. The project involved reclamation of locally sourced materials and timber taken from Poplars (*Populus nigra*) on nearby parkland. The garden received funding from the Safer Stronger Communities Fund for Old Trafford. The site is managed primarily by local community members in conjunction with Seymour Park Community Primary School which is situated directly adjacent to the garden (Trafford Partnership, 2010).

#### 2. Fallowfield Secret Garden

Fallowfield Secret Garden was situated on derelict incidental green space owned by City South Housing Association that was handed over to residents. A local housing association tenant was chosen to manage the project which has since developed into an educational project employing permaculture principles to promote local sustainable living (City South Manchester, [no date]). A view of part of the site is presented in Figure 5.1.



Figure 5.1 Fallowfield Secret Garden community garden: growing area. (September 2013).

### **3. Barlow Moor Road Community Garden**

Barlow Moor Road Community Garden was the result of co-operation between local social landlords and the community food-growing group Didsbury Dinners. The site was previously derelict and subsequently transformed into a space for gardening by local volunteers (Action for Sustainable Living, [no date]).

#### **5.1.2 Community allotments**

### **4. Planting and Learning Old Trafford (PLOT)**

PLOT is situated within Seymour Grove Allotments in Old Trafford and was formed through partnership between Trafford Council and BlueSci, a local community well-being centre. The project is run by experienced allotment gardener volunteers (Action for Sustainable Living, [no date]).

### **5. Moss Side Community Allotment**

Situated in council owned allotment land in South Manchester, Moss Side Community Allotment was established with the cooperation of Adactus Housing Trust. Starting in 2012 the project received a Food Poverty Award in 2014 to help continue their work (Adactus Housing, 2014).

### **6. Grow For It Chorlton**

Grow For It Chorlton is situated on Scott Avenue Allotments Site in South Manchester and is a community-run project promoting sustainable living, carbon reduction and organic food production since 2009 (Chorlton Life, 2012). The site also contains an apiary and a small orchard area (Figure. 5.2).



**Figure 5.2 "Grow For It" community allotment, Chorlton. View towards Scott Avenue Allotments. (September 2013).**

### **5.1.3 Community orchards**

#### **7. Stenner Lane Community Orchard**

Stenner Lane Community Orchard was established on an unused section of recreational land owned by Didsbury Toc H Rugby Club in 2011 by local volunteers with the assistance of Didsbury Dinners Growing Group, funded by sales from their sustainable food cookbook (Didsbury Life, 2012).

#### **8. Birch Fields Forest Garden**

A permaculture designed edible garden situated in parkland within Birch Fields in Longsight, Manchester, the project was created by the Birch Fields Green Action group under the guidance of the Friends of Birch Fields Park. The site became a site of the Agroforestry Research Trust in 2012 and hosts regular work days promoting forest gardening and permaculture principles (Manchester Climate Monthly, 2012).

#### **9. Philips Park Community Orchard**

The community orchard in Philips Park was created in 2009 in East Manchester parkland through collaboration between a network of local community service providers and the Community Orchards Working Group (Manchester Evening News, 2009). The site is situated

adjacent to private allotment gardens also within Philips Park (Figure 5.3).



**Figure 5.3 Philips Park Community orchard. View towards allotment site (September 2013).**

#### **5.1.4 Pocket parks**

##### **10. Dale Street Car Park**

The creation of grow boxes and fruit tree planting on a car park in central Manchester was the result of a partnership between the Northern Quarter Greening Group of local residents, the city centre management and marketing group CityCo Manchester, and the land owners (CityCo, 2013). It is one of a small network of similar sites around the city centre aimed at promoting wildlife and sustainable living. The site is comprised mainly of “grow boxes” (Figure 5.4).



**Figure 5.4 Pocket park on Dale Street car park. View towards Northern Quarter (September 2013).**

### **11. The Triangle**

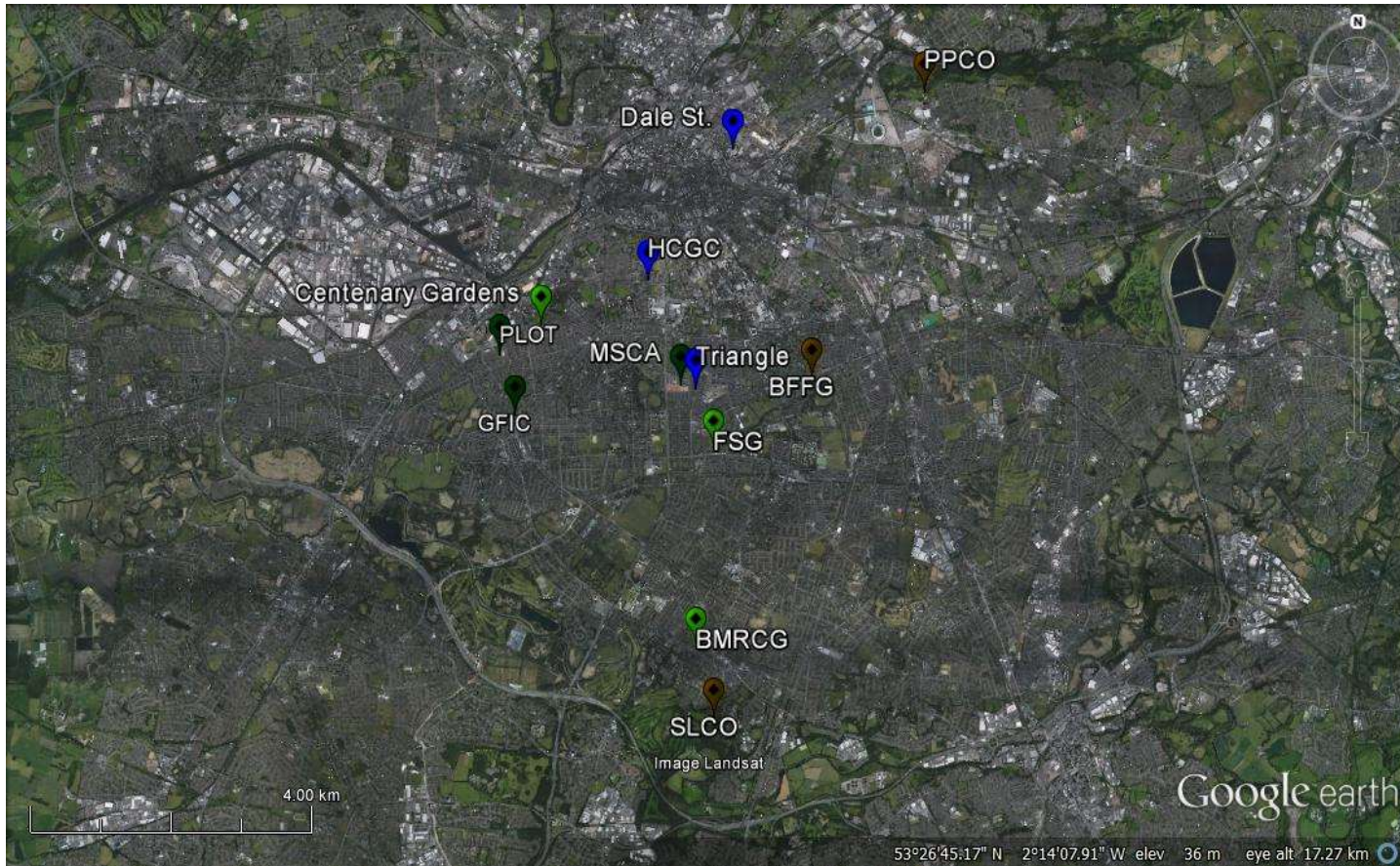
The creation of Cranswick Square community garden, also known as the “Triangle” was the result of concerted efforts by members of the local Cranswick Square Residents Association in 2010 to transform a pocket of DUN land into a community space for events and food growing (Cranswick Square Residents Group, 2011).

### **12. Hulme Community Garden Centre**

Started in 2000, Hulme Community Garden Centre was created to provide functional and educational green space to local residents in the Hulme area. It since became a not-for-profit organisation and currently operates a social prescribing service (HCGC, [no date]). In 2011 the centre acquired a lease for an adjacent area of disused car park. The case study site is taken from the initial development of a section of the car park into an improvised growing and educational space.

Figure 5.5 presents the relative locations of the case study sites.





**Figure 5.5 Location of case study sites (Google Earth, 2015).**

**Site Key:**

**FSG = Fallowfield Secret Garden, BMRCG = Barlow Moor Road Community Garden, PLOT = Planting and Learning Old Trafford, MSCA = Moss Side Community Allotment, GFIC = Grow For It Chorlton, SLCO = Stenner Lane Community Orchard, BFFG = Birch Fields Forest Garden, PPCO = Philips Park Community Orchard, HCGC = Hulme Community Garden Centre.**

### **5.1.5 Ecosystem services selected for study**

In order to evaluate and compare the ecosystem services produced by each site, a selection of services were chosen which were relevant to, but limited in, urban areas according to the UK NEA (2011). The specific services evaluated were:

- i) Microclimate regulation
- ii) Food Production
- iii) Biodiversity potential
- iv) Education and well-being

The services outlined above were selected as they comprised the most salient with reference to the sites themselves as well as being of the most important for the urban environment as stated in the UK NEA (UK NEA, 2011: Chapter 10, page 75). Including additional services may have been ineffective to the findings of the research due to incongruence. There would be little research advantage in choosing to measure services related more closely to other ecosystem types such as timber production and carbon sequestration when attempting to map the services existing in and beneficial to the urban environment. In this way it has been possible to keep the services selected site-relevant as well as pertinent to the localities in receipt of those services.

Data collection methods were explored by carrying out an extensive review of existing research and practice in the field of ecosystem services and environmental accounting whilst conducting on-going case study site visits to establish the applicability of possible methods and tools (or modifications thereof) in the data collection process. Details of each data collection method are described in section 5.2.



## 5.2 Data collection methods

Initial case study site surveys took place during the case study selection process. After the selection of cases was finalised, further surveys were undertaken to record site layout, the details of which were then employed in the subsequent assessments of ecosystem services as detailed in Sections 5.2.1 to 5.2.4. The case study approach involved multiple visits to the sites and consultations with primary site managers/project leaders. As such it was possible to collect data from multiple sources simultaneously in a continued fashion. For example, data gathered whilst recording site layout for the GI toolkit was equally employed in the evaluation of site cultivation and served to ratify land-cover estimates employed in the biodiversity rapid assessment. Similarly, it was often possible to combine data collection methods, namely site surveying, direct observations and consultations during a particular site visit. Sites were thereby visited on multiple occasions from initial scoping visits in early 2013 which helped to confirm the suitability of data collection methods. Further visits were made in order to carry out site surveys and record dimensions for use in the microclimate regulation evaluation (April to September: methods presented in Section 5.2.1) and assessment of food production (methods: Section 5.2.2). Site biodiversity assessments were then conducted during the summer months (June to August) and the collection of data related to education and well-being was carried out between March 2013 and December 2013 (see Section 5.2.4 for details).

### 5.2.1 Microclimate regulation

For urban areas to be liveable residential zones the adequate provision of vital ecosystem services which contribute to the regulation of microclimate conditions and water attenuation is of great importance. Few considered attempts have been made to put together a tool kit to provide accurate accounting of the effects of differing vegetation structures and mosaics on issues such as cooling and heating of the urban microclimate. Similarly studies into reduction in wastewater treatment, through run-off intercepted by green elements in urban micro-scapes, are hitherto underdeveloped.

One such attempt has been the *Green Infrastructure Valuation Toolkit* created by Green Infrastructure North West (2010) which echoes the ecosystem services framework but which re-categorises such services as an inventory of 11 *environmental benefits*. Being a valuation toolkit, it is largely based on a monetary assessment of green space developments. Given

that OSEI consisted chiefly of small-scale community-managed spaces such an approach did not address the site specific concerns and values which a given community attached to their local spaces. That is to say that OSEI exhibited a variety of management approaches based on local preferences. An appreciation of the dynamics of ecosystem benefit production and subsequent trade-offs, would be better achieved through alternative non-monetary evaluation methods which did not prize certain goods and services over others. A calculation of the projected value of OSEI for the study area as a whole is dealt with separately in Chapter 6. Other similar tools have emerged to monitor and place value on natural capital but of those researched most were found to be incomplete, lacking in terms of evidence base, or aimed primarily at landscape-scale ecological processes. As such, most were not adaptable to the scale and detail required for a realistic evaluation of the chosen sites in this case-study.

One tool found to be readily applicable to various scales without reducing the accuracy of the result was a management tool based on the concept of “ecologically effective area”. It has appeared in several versions and is known by various names, depending on the country in which it has been applied and used, but principally the *Biotope Area Factor Tool* or the *Green Space Factor Tool*. This tool has been primarily applied as a rapid assessment urban planning tool with the aim of predicting the overall ecological impact of a given development proposal. The tool was first designed for use in the Berlin and Hamburg metropolitan areas by the German Senate Department for Urban Development and the Environment in the 1990s under the terminology *Biotope Area Factor*. The authors of the tool described its rationale as follows: “The biotope area factor (BAF) designates the ratio of areas of a site that have a positive effect on the ecosystem or an effect on the development of the biotope of a site in relation to the entire area of the site.” (Becker and Mohren, 1990, p.2). The basic premise of the tool is to create a score ranging from zero to one based on the surface area cover types as well as secondary and (in later versions) tertiary layers (made up of structural elements such as shrubs, trees, green roofs/walls and water harvesting systems). In this way it gives a three dimensional appraisal of the site in question, taking into account area cover types as well as vertical elements. In essence, the score resulting from the tool, ranging from 0 to 1, represents the proportion of a site which can be considered ecologically effective. However, with the consideration of secondary and tertiary “layers” it is in fact possible to achieve a score higher than 1, though this is unusual in urban areas.

Weightings are assigned to each category of surface cover as a reflection of their ecological integrity and this value is multiplied by the total area in square metres of each present at the target site. The overall site score is then calculated as the ratio of the combined total value of all surface types to the total area of the site in question. The weightings of the BAF have been adapted to varying degrees by later version of the tool but those of the original tool were as follows (Table 5.1):

**Table 5.1 Biotope Area Factor weightings/descriptions.**

<b>Surface Type</b>	<b>Weighting Factor</b>	<b>Surface Description</b>	<b>Examples</b>
Sealed surfaces	0.0	Surface is impermeable to air and water and has no plant growth. No infiltration. No soil function.	Concrete paving, asphalt, slabs with a solid sub-base.
Partially sealed surfaces	0.3	Surface is permeable to water and air; some infiltration; as a rule, no plant growth.	Stone/mosaic paving, slabs with a sand or gravel sub-base.
Semi-open surfaces	0.5	Surface is permeable to water and air; some infiltration; some plant growth.	Gravel with grass coverage, wood-block paving; honeycomb brick with grass.
Vegetation not connected to soil below (<80cm)	0.5	Vegetation with less than 80 cm of soil depth.	Raised beds, roof of underground parking.
Vegetation not connected to soil below (≥80)	0.7	Vegetation with 80cm soil depth or greater.	As above.
Vegetation connected to soil below	1.0	Vegetation connected to soil below, available for development of flora and fauna.	N/A
Rainwater infiltration (per m <sup>2</sup> of roof area).	0.2	Rainwater infiltration over surfaces with existing vegetation.	Any built structures with roofs draining onto vegetation.
Vertical greenery up to max. 10m height	0.5	Greenery covering walls and outer walls with no windows.	Green facades.
Green roofs	0.7	Extensive and intensive coverage of rooftop with greenery.	N/A

(Adapted from Senate Department for Urban Development and the Environment – Berlin (2013)).

Once a survey of a given site has been carried out, a simple calculation is then required to obtain the BAF:

$$\text{BAF} = \frac{\text{Ecologically Effective Surface Areas}}{\text{total courtyard area}} \text{ i.e. } (\text{area A} \times \text{factor A}) + (\text{area B} \times \text{factor B}) + (\text{area C} \times \text{factor C}) + (\text{area n} \times \text{factor n}) / \text{total courtyard area}$$

A worked example is presented in Table 5.2:

**Table 5.2 Worked example of BAF tool.**

			<b>Total site area (m<sup>2</sup>)</b>	<b>= 500</b>
<b>Surface type</b>	<b>GI factor</b>	<b>Area (m<sup>2</sup>)</b>	<b>Ecologically effective area (m<sup>2</sup>)</b>	
Concrete paving	0	300	0 x 300 = 0	
Gravel coverage	0.5	175	0.5 x 175 = 30	
Raised beds (90cm soil depth)	0.7	15	0.7 x 15 = 10.5	
Open soil	1	10	1.0 x 10 = 10	
<b>Total ecologically effective area (m<sup>2</sup>)</b>			<b>= 50.5</b>	
<b>BAF = ecologically effective area/ total site area</b>			<b>= 50.5/500 = 0.1</b>	

As can be seen in the above example the tool was well adapted to the urban environment and designed to be applied on small-scale “courtyards” – where built and natural elements intersect and overlap. As such the method had to acknowledge the varied surface types as well as the often complex vertical elements which are to be found in the urban environment. As such it avoids an over-simplified appraisal of land cover as either “built” or “green” in order to capture the ecological characteristics of our city spaces, as specified in the original expert paper on the objectives for development of the tool (Becker and Mohren, 1990). The tool was designed in conjunction with environmental policies with the aim of achieving a minimum requirement of ecologically effective green space and as such target BAF scores were designated for various types of development. The plans of any given development had to demonstrate that any proposed changes would meet the minimum required BAF factor for that type of development. Although initial examples of usage focussed on relatively small urban “courtyards”, the straight-forward scoring method of the tool has allowed it to be adapted to much larger sites and even used to achieve an overall score for whole cities as in the case of Southampton in the UK in 2012 (Phillips and Moore, 2012).

The BAF was developed further by planning authorities in Sweden where it was adapted in 2001 for the Malmö *Green Space Factor* (GSF). The tool was used following the same principles as in Berlin and Hamburg though weightings were customised and different

requirements for sites were applied appropriate to the local environment and planning policies. As well using the GSF score, a checklist of points known as the *Green Points System* was created to allow for more robust planning constraints. Developers were given a list of 35 Green Points and were required to choose 10 of them to meet the environmental requirements. Several versions of the GSF have been created in Malmö since as planning considerations have been updated (Krause, 2011).

More recently (2006), a version of the tool appeared as the *Green Factor* tool for the first time in the United States in Seattle. Again building on previous versions of the tool, the Seattle Green Factor has been modified only to a minimal degree to fit with the planning priorities and climate of the area; the principle concept of the biotope/area ratio is intact. The Malmö green points systems has been included and further guidelines for developers were added including recommended and prohibited tree and plant listings.

In the UK, the Malmö GSF had been adopted by several partner agencies in the Pan-European Green and Blue Space Adaptation for Urban Areas and Eco Towns (GRaBS) project, including the London Borough of Sutton, the (now defunct) Northwest Regional Development Agency (NWDA), Southampton City Council and the Town and Country Planning Association. The Malmö GSF was adopted almost seamlessly in the UK by Sutton and Southampton councils but was modified to some degree by the Northwest Development Agency to support the existing green infrastructure objective which had already been put in place as part of a policy to support a natural economy approach to environmental management in North West England (Krause, 2011). To this end the NWDA developed the Green Infrastructure Toolkit (Green Infrastructure North West, 2010) which was still aimed at informing and constraining land developments but which took a GI-centric approach and incorporated elements of the BREEAM sustainable development framework. The tool adopted the “very good” score of the latter as its standard for land cover configurations, to be used and understood by developers. The Green Points System was adapted to provide a list of GI Interventions with the aim of fulfilling one or more of the 11 economic benefits of green infrastructure as outlined in the NWDA’s Sustainability Policy for the Built Environment (Gill, 2010). The method is again in keeping with the original concept of the BAF with only slight modifications to the weighting of certain surface types.

It is this latter version of this tool that was adopted in the methods of this thesis as it provides the most updated version available and, being developed for use in the North West

of England, fits in with the context of the study area and will therefore also be comparable with other reports from the North West. One important change was made to the GI toolkit for use with the case-study sites of this thesis – the addition of the “rainwater infiltration per roof area” factor of the original BAF tool. This factor had been removed from later versions of the tool and is absent from the GI Toolkit to no advantage as far as the author of this thesis is concerned. The inclusion of this factor, however, adds an added level of detail to site evaluations, especially given that this element featured significantly in most of the case-studies surveyed.

For the purposes of this research the tool has been applied to give a score for the current status of the ecological character of a site without the need for a “before and after” scenario type of comparison for which it was originally designed. The relatively simple, modular nature of the tool allowed for this modification to be applied without any significant changes necessary to the method.

The GI toolkit has been chosen as one which can provide an indicator of the quality of and/or potential for microclimate regulation services given that the original premise of the tool is to quantify the ecological effectiveness (or, the quality of ecological functions) inherent in the physical characteristics of a given site. The concept of ecological effectiveness as put forward by the authors of the original Biotope Area Factor framework is directly related to the provision of ecosystem services (Phillips and Moore, 2012). This is reflected in the ecological goals targeted by the original BAF concept, namely: improvement of the microclimate and air hygiene quality, safeguarding soil function and the efficiency of water management, and increased provision of habitat for plants and animals. These goals are achieved by the BAF through protection of ecological functions which underpin those services of greatest salience in the context of the urban environment, namely:

1. high evapotranspiration efficiency,
2. high capacity for binding dust,
3. infiltration ability and storage of rainwater,
4. long term guarantee of the conservation of soil function,
5. availability of habitat for plants and animals. (Becker et al., 1990).

It could, therefore, be said that the promotion of ecologically effective areas as outlined in the original BAF and subsequent versions support the conservation and creation of a range of ecosystem services across regulating, provisioning, supporting and cultural categories. It

shall be used in this thesis however, primarily as an indicator of the quality of microclimate regulation (including water attenuation and air temperature regulation) provided by the case-study sites. The reason for this is that the majority of the criteria which achieve the targets of the original BAF tool (stated above) are those ecological functions underpinning such regulating services. That is to say that these services depend directly on the presence, quality and structure of vegetative elements in the landscape and it is similarly these elements upon which the original BAF scoring is based. As such this premise has been adopted in the methods of this research through the application of the GI toolkit as a modified version of the BAF in the context of the policy and urban character of England's North West. The assessment of effectiveness is derived, generally speaking, from the presence of vegetative structures and further informed by the level of succession involved in such structures and finally, the additional "artificial" functions from man-made elements such as swales or other water-harvesting features.

Data were collected from each site through field measurements during detailed site surveys and attributing the relevant surface type designated within the GI toolkit to that observed on-site. The data were then entered directly into the GI toolkit sheet (see Appendix 2 for details), the results of which are presented in Section 5.3.2. The toolkit is available for download from the GI North West website at: <http://www.ginw.co.uk/climatechange>

Data were collected during site surveys which were carried out between April to September 2013. On each occasion, a single site visit was sufficient to complete the assessment.

### **5.2.2 Food production**

In the case of those sites of social-ecological innovation observed and recorded in the mapping exercise, the principal provisioning service was found to be food production. In order to achieve an estimate for each site of the potential capacity to produce viable crops in its current state of management, a proxy was used based on detailed harvest reports that had been carried out across community gardening sites in Philadelphia, Camden (Penn.) and Trenton (NJ), in the United States. The reports were compiled by the Urban Agriculture and Community Food Security research group, directed by the University of Pennsylvania. The proxy was acquired by taking mean yields per unit site area under cultivation of gardens in the Philadelphia Harvest Report (Vitiello and Nairn, 2009) and applying this factor to the



case-study sites selected for this thesis. Gardens included in the Philadelphia Harvest Report were categorised by site area. For all (five) categories of site area below two hectares, the mean site productivity in terms of food yield was equal to  $6.93 \text{ kg m}^{-2}$  (converted from  $\text{lbs ft}^{-2}$  in the original report, see Appendix 4). Although the Philadelphia/New Jersey area has a different latitude to the study area in this thesis, the climatic conditions are comparable and for the purposes of this research serve to provide relative indicators of potential food yields between the case-study sites.

Other factors such as site area, percentage of each site under cultivation and crop type were recorded for comparison. In the case of orchards and other sites partially designated to fruit production projected yields per square metre were calculated from the UK government Basic Horticultural Statistics dataset (Defra, 2013). Where fruit production was prominent, crop yields were estimated based on whether soft or hard fruits were in cultivation. For hard fruit, average orchard yields per square metre were calculated at  $1.5 \text{ kg m}^{-2}$  (UK commercial mean yields 2007 – 2011: Defra, 2013) and used as a proxy. For soft fruit, a proxy value of  $1.39 \text{ kg m}^{-2}$  was calculated from national mean soft fruit yields 2007 – 2011 (Defra, 2013). Full details of calculations through which proxies for food production were obtained are presented in Appendix 4.

Data for food production at each site were collected simultaneously as part of the survey carried out for microclimate regulation in which each surface cover type was recorded in detail. Areas which were designated for crop cultivation were recorded as such during the process of carrying out site surveys and subsequently used to give an estimate of likely summer harvest potential.

Data were gathered concurrently with those for microclimate regulation which involved accurate measurement of site dimensions and land-cover (April to September 2013).

### **5.2.3 Biodiversity potential**

For the purposes of achieving quantifiable measures of biodiversity potential as an ecosystem service provided by sites of social-ecological innovation, a rapid assessment approach to site evaluation was employed. The survey method used was developed at the University of Salford (Tzoulas and James, 2010) and focusses on vegetation structure whilst employing biodiversity surrogates, Tandy's Isovist technique and the Domin scale (Sutherland, 1996). This provides a rapid assessment method of biodiversity for use in urban

environments. In the assessment, the percentage cover of each type of vegetative structure (defined using categories developed by Freeman and Buck (2003)) is estimated using a method adapted from Tandy's Isovist technique (Westmacott and Worthington, 1994). This measure is then combined with the number of genera of vascular plants observed to give a combined score for overall biodiversity. The tool is applied in a three-step process. Firstly, an initial score is given for each vegetative structure present as categorised by the Domin scale which is a quantitative measure of land cover by vegetation types or species ranging from 1 (<4% land cover) to 10 (91% to 100% cover) as outlined in Table 5.3.

**Table 5.3 Classification of vegetative structure Domin values in Tzoulas and James (2010).**

Vegetation Structures	Height	Domin Value									
		1	2	3	4	5	6	7	8	9	10
High trees	10 m										
Low trees	5 - 9.9m										
Bushes	1 - 4.9 m										
High grasses and forbs	20 cm - 99 cm										
Low grasses and forbs	5 cm - 19 cm										
Ground flora	< 5 cm										
Aquatic											
Built											

**Domin values = 1:** < 4% cover with few individuals; **2:** < 4% with several individuals; **3:** < 4% with many individuals; **4:** 4-10 %; **5:** 11-25 %; **6:** 26-33 %; **7:** 34-50 %; **8:** 51-75 %; **9:** 76-90 %; **10:** 91-100 % cover

For each structure present a score of 1 is allocated and the total is then modified by adding or subtracting points based on the Domin score for site built surface cover. This modification of the score is based on the premise that built surface cover, although able to support early succession vegetative structures, has a primarily deleterious effect on overall site biodiversity. Accordingly, points are added or subtracted from the initial score for number of discrete vegetative structures in the following way:

**Table 5.4 Modification of biodiversity score according to built layer Domin value (Tzoulas and James, 2010).**

-1 point for built layer Domin 6;	+1 point for built layer Domin 5;
-2 for built layer Domin 7;	+2 for built layer Domin 4;
-3 for built layer Domin 8;	+3 for built layer Domin 3;
-4 for built layer Domin 9;	+4 for built layer Domin 2;
-5 for built layer Domin 10;	+5 for built layer Domin 1.

Finally, a score based on the number of genera of vascular plants present (one point for every 6 genera recorded) is calculated and added to the previous figure to give an overall biodiversity measure. To give a worked example, a site containing 5 discrete structural elements (Table 5.3) and built surface cover of 4 on the Domin scale (Table 5.4) with 42 genera of vascular plants recorded would result in a score of 14 (i.e.  $5 + 2 + (42 \div 6) = 14$ ). The data recording sheet used in the assessment is presented in Appendix 6.

In a sense the method is limited as it does not take into account other taxa such as birds, mammals or invertebrates. A more detailed survey however might prove to be ineffective given the high level of urbanisation of these sites, their relatively small area and the high levels of disturbance symptomatic of urban development which would make other bio-diverse elements difficult to sample. Although straightforward in approach the method gives accurate, comparable biodiversity measures for a variety of green space types. A fuller explanation of the background to the biological surrogates and scales used in the method as well as a rationale of the scoring system can be found in Tzoulas and James (2010).

Data were collected using a checklist to record vegetative structure, characteristic species and number of vascular plant genera. The original method was modified in order that it could be better applied to the case study sites. The method was piloted on areas considerably bigger than those sites selected for this research and, for practical purposes, circular sampling points consisting of a minimum of 10% of the total site area were established and surveyed. As all sites selected as case studies in this work were considerably less than one hectare it was possible for the sites to be sampled in their entirety by using the original visual estimate technique to record vegetative structure from a single vantage point and by subsequently employing line transects to identify and record vascular plant species. Furthermore, detailed site surveys were carried out in the data collection process for microclimate regulation and crop yield. It was therefore possible to ratify estimates of land

cover using accurate site plans. Results of the survey are presented in Section 5.3.4. The case study assessments of biodiversity potential were conducted as a single visit for each site and in fair weather conditions during the summer months June to August 2013. The assessments thereby constituted a snapshot perspective, which was consistent with the evaluation of food production and microclimate regulation.

#### **5.2.4 Education and well-being**

Few comprehensive attempts have been made to quantify in detail urban cultural ecosystem services provided by small or incidental urban green spaces. In terms of this thesis an evaluation of site-specific cultural services was enabled through the assimilation of indicators taken from Natural England (2012) protocols together with direct observations relating to the site accessibility and embeddedness in the physical locale. Data were gathered on cultural ecosystem services through the application of selected indicators from Natural England's monitoring and evaluation protocols for the socio-cultural benefits that individuals and communities receive from interaction with quality green space (Natural England, 2012). These protocols were prepared for the Nature Improvement Area scheme and are listed under the indicator sub-theme: *social impacts and well-being* (Natural England, 2012). From these protocols, two were selected which were of most direct relevance to the nature of the activity and level of community participation taking place at the case-study sites as well as to urban cultural ecosystem services in general. These were *Volunteer Hours* and *Educational Visits*. Evidence of both of these indicators was gathered from site facilitators at case-study sites or, where this role was not explicit, from prominent site users. Information on volunteer hours per month during the growing season (March to October (DECC, 2013)) was gathered as a measure of community involvement. Volunteer hours relating specifically to physical activity were recorded; data relating to administration activities were not included in the analysis. The number of educational and community events which take place at each site over the course of a year was equally recorded as an additional measure of cultural ecosystem services provision following the rationale of the Natural England protocols. As such, these data served as proxy measures for the contribution to community education and well-being provided by each site based on the Natural England protocols and further supported by findings in the literature which highlight

the strong links between urban green space, outdoor activities, and human health (see literature review, Sections 2.4 and 2.5).

Specifically, data on volunteer hours and educational and community events relate to (individual and social) well-being as asserted by the UK government Department of Environment, Food and Rural Affairs' attempts to outline a common understanding of the term. Defra's 2007 Well-being and the Natural Environment Report, states that well-being "is enhanced by conditions that include supportive personal relationships, strong and inclusive communities, good health, financial and personal security, rewarding employment, and a healthy and attractive environment" (Newton, 2007, Box 1, p.7). Both individual involvement with local green space management, as denoted by figures for volunteer hours, and the provision of educational and other community events at OSEIs, contribute directly to community inclusiveness, interaction with naturalistic environments and promotion of healthy activities.

These two elements reflecting volunteer input and educational events were combined to create an overall impression of benefits to community education and well-being. Figures for volunteer hours per month and number of events per year were summed which gave a measure of community involvement. The resulting score represented a community benefit factor (CBF) associated with each site and was used as a proxy for the provision of the co-produced ecosystem services *education and well-being*.

These data were collected from site managers/project facilitators via correspondence or during site visits according to access and availability of sources. This element of data collection was therefore conducted in a more ad-hoc fashion than for other ecosystem service assessments over a period spanning March 2013 to December 2013.

### **5.2.5 Site access and setting**

Data relating to accessibility of each site were also collected. This involved acquiring information on public access, opening times (if applicable) and visibility from the street in order to add an extra dimension to the evaluation of the social impact of a given site. Again such information was gathered from site facilitators and by direct observation. In particular, these factors served as an indication of site integration into the immediate locality and as such gave an impression of the contribution of sites to local sense of place. The latter has

been cited as a key element in community identity and well-being (Williams and Stewart, 1998; MEA, 2005; Davenport and Anderson, 2005) and, moreover, studies have demonstrated that naturalistic spaces and healthy urban environments can be instrumental in creating a positive sense of place amongst communities (Stedman, 2003; Kudryavtsev et al., 2012).

### **5.2.6 Presentation of data**

An initial description of case study sites is provided with site layouts drawn from initial site surveys. Following this the results of each assessment for the four ecosystem services studied are presented in Section 5.3 by category, in the following order: i) microclimate regulation, ii) food production, iii) biodiversity potential and, iv) education and well-being. Data is presented for comparison between individual sites and then between OSEI type, as defined in Chapter 4: namely, community gardens, community allotments, community orchards and pocket parks. Basic, descriptive statistics were performed on the data for each assessment with further analysis drawn to highlight variability of service provision. Trade-offs and synergies between services are subsequently analysed in Chapter 6.

The assessment of microclimate regulation services provided by case-study sites was based on the principles of the GI Toolkit which took the proportion of sites which could be deemed ecologically effective as its rationale. The method therefore constituted an area-specific approach. This particular quality of the tool was one of its strengths in that it allowed for a standard, reliable approach to the assessment at various scales, normalising for discrepancies in site size. This spatially oriented perspective is particularly effective in the evaluation of diverse heterogeneous urban spaces for which the original tool was designed. Adopting this basic quality of the GI Toolkit methodology, an evaluation of services standardising for site size, was continued throughout the analysis for all services. Accordingly, ecosystem service scores are presented in the following sections of this chapter, firstly as “raw” values resulting from each assessment and subsequently standardised by site area.

## **5.3 Case study results**

Site information in terms of size (measured in the field during data collection for microclimate regulation and food production), layout and location is initially presented in

Table 5.5 and Figures 5.7 to 5.30 in Section 5.2.1. Ecosystem service assessment data and subsequent analyses are then presented in sequence for each service in Sections 5.3.2 to 5.3.5. Table 5.5 presents site dimensions and basic background information.

**Table 5.5 Key and basic site information.**

Garden	Total Area (m <sup>2</sup> )	Mean Area (m <sup>2</sup> )	Primary Leader/ Gatekeeper?	Main Partners/funders	Main users	Year Started
Centenary	936	766	No	Trafford safer stronger communities fund/Trafford Partnership	School and local residents	2007
FSG	1530		Yes	City South Housing Association	Local residents and external volunteers	2012
BMRCG	560		No	Didsbury Dinners community interest company	Local residents	2012
PLOT	950		No	Trafford Council, Bluesci social enterprise	Local residents and BlueSci service users	2009
MSCA	780		Yes	Adactus Housing Association	Local residents and school visits	2011
GFIC	630		Yes	Manchester City Council	Local residents and school visits	2009
SLCO	1044		No	Didsbury Dinners community interest company	Local residents	2011
BFFG	1734		Yes	Manchester City Council/Friends of Birch Fields Park	Local residents and Friends of Birch Fields	2007
PPCO	380		Yes	New East Manchester, 4CT, Community Orchards Working Group and Manchester City Council	Residents, community payback and schools groups	2009
Triangle	215		Yes	Manchester City Council/Adactus Housing Association	Local residents	2011
Dale St	221		No	Manchester City Council, City Co Manchester	Public use and Northern Quarter Greening Group	2011
HCGC	217		Yes	Self-funded not-for-profit	Community payback groups, schools, local residents and social prescribing	2012

Type key:

community gardens
community allotments
community orchards
pocket parks

Mean area = 766 ±502 Coefficient of Variation = 0.66

Site Key: FSG = Fallowfield Secret Garden, BMRCG = Barlow Moor Road Community Garden, PLOT = Planting and Learning Old Trafford, MSCA = Moss Side Community Allotment, GFIC = Grow For It Chorlton, SLCO = Stenner Lane Community Orchard, BFFG = Birch Fields Forest Garden, PPCO = Philips Park Community Orchard, HCGC = Hulme Community Garden Centre.



### **5.3.1 Case study site descriptions: initial surveys**

Information on site management and design for each of the chosen case-studies was gathered by initial site visits and surveys undertaken to establish site layout. Although general similarities across sites were present, cases differed according to their typology. Schematic diagrams of the site layout of each case study together with aerial images of case study locations are presented in Figures 5.6 to 5.29.

#### **i) Community gardens: site 1. Centenary Gardens**

Centenary gardens were located adjacent to a local primary school and municipal park. The contained multiple recreational and amenity design components, was open to the public during daylight hours and featured perimeter fencing which offered a measure of security. The site was visible and accessible from street level. A schematic diagram of the site is presented in Figure 5.6 and an aerial view of site location in Figure 5.7.

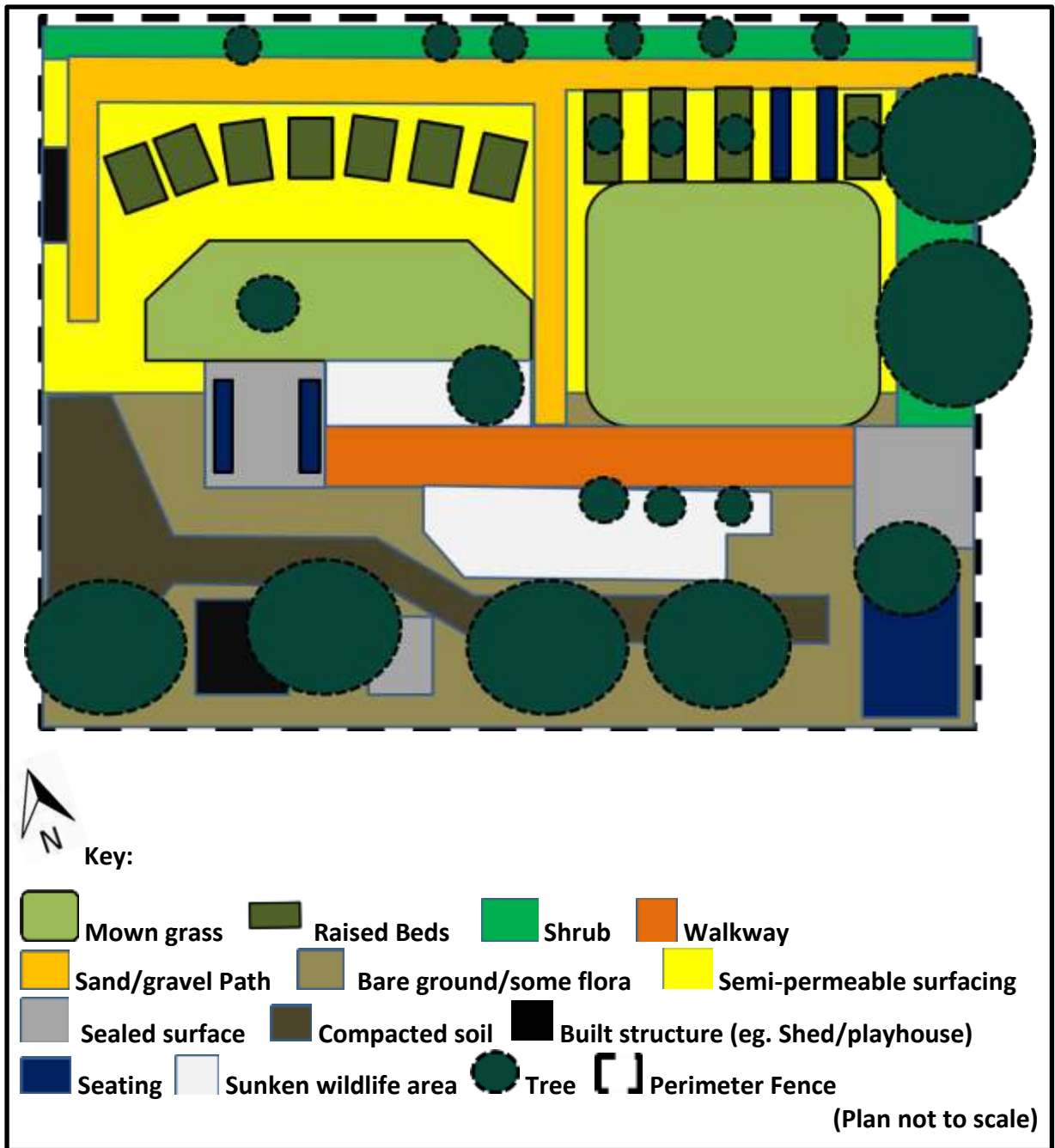


Figure 5.6 Centenary Gardens schematic plan.



**Figure 5.7 Location of Centenary Gardens (Google Earth, 2015).**

### **Site 2. Fallowfield Secret Garden**

Access to Fallowfield Secret Garden was limited and the site was open to volunteers and members of the public during specific times of the week (four days per week, 10am – 4pm). Perimeter fencing ensured privacy and security to the site. The site offered basic facilities such as toilets, shelter and communal seating areas. Recreational and educational facilities/activities were provided for children. The garden was situated in a residential area of South Manchester with a large municipal park nearby (Platt Field's Park). A schematic diagram of the site (not to scale) is presented in Figure 5.8 and location in 5.9.

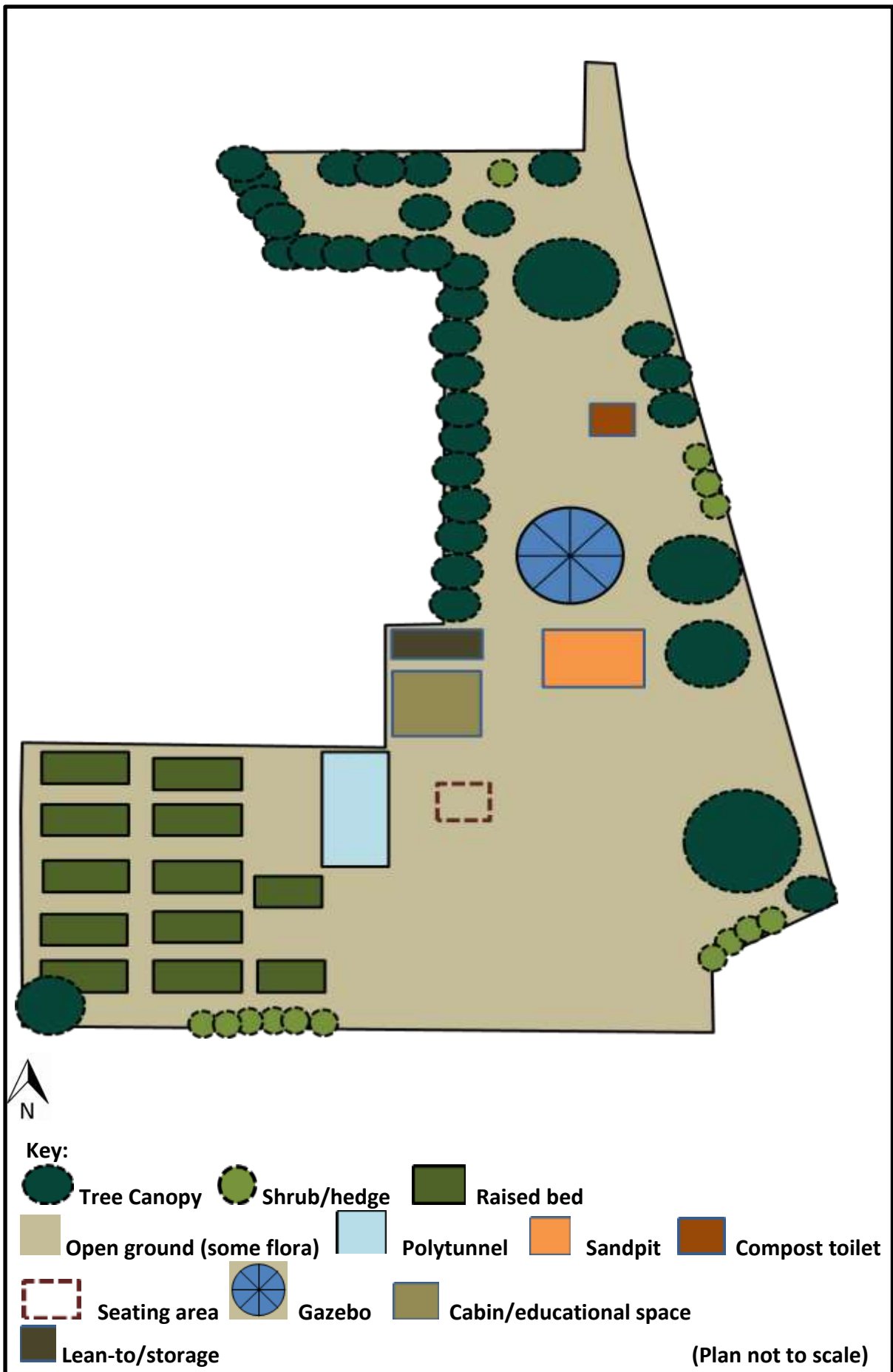


Figure 5.8 Fallowfield Secret Garden schematic plan.



**Figure 5.9 Location of Fallowfield Secret Garden (Google Earth, 2015).**

### **Site 3. Barlow Moor Road Community Garden (BMRCG)**

BMRCG was situated at the rear of residential property to the west of Didsbury high street. Access to the site was private with organised “work days” which took place approximately every two weeks during the growing season. The primary activity at the site was food production with few amenity or recreational features. A schematic plan and aerial view of the site are presented in Figures 5.10 and 5.11.



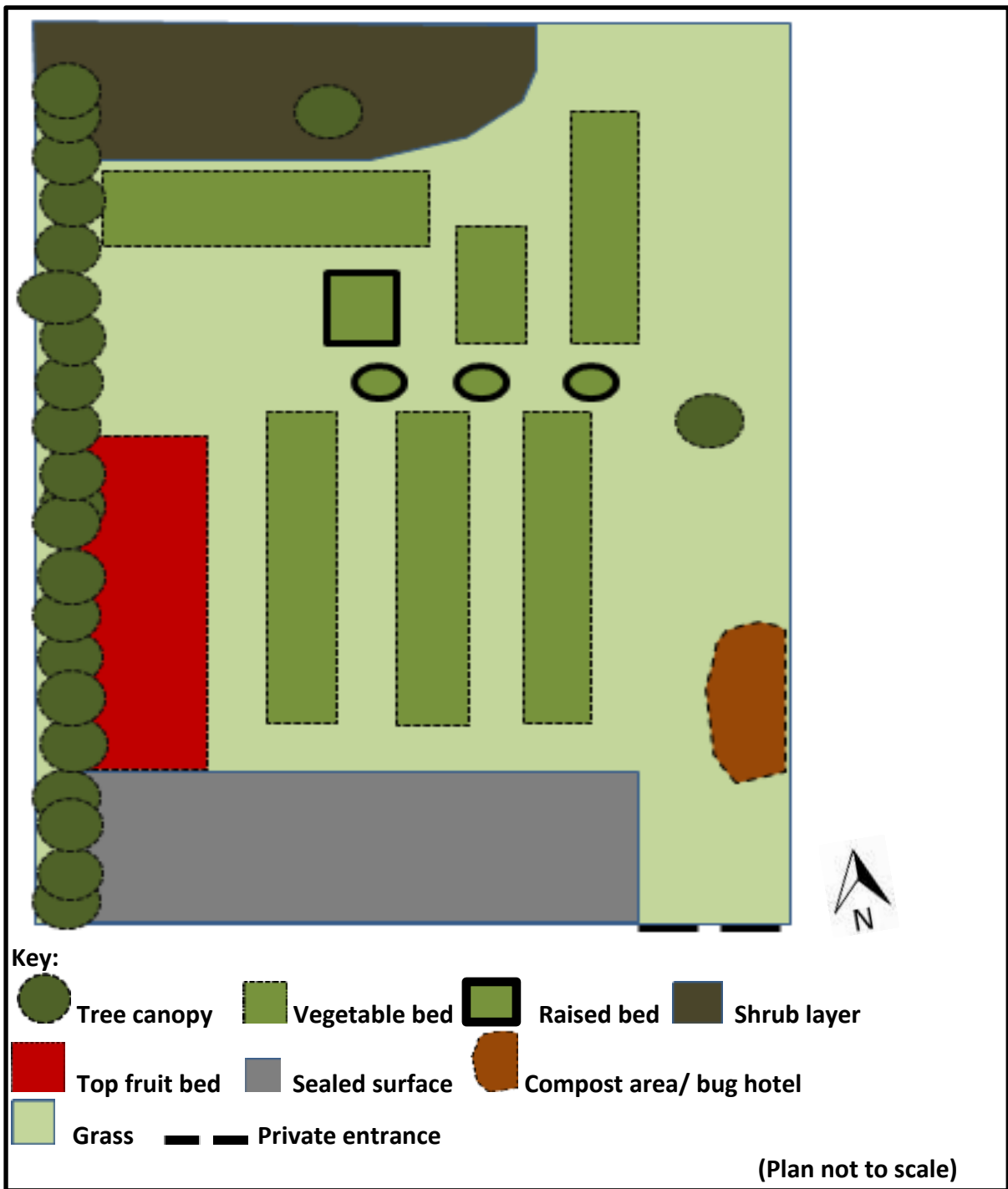


Figure 5.10 Barlow Moor road community garden schematic plan.



**Figure 5.11 Location of Barlow Moor Road Community Garden (Google Earth, 2015).**

**ii) Community allotments: Site 4. Planting and Learning Old Trafford (PLOT)**

PLOT was located at a designated allotment site and as such was subject to limited access. The site was open to volunteers during twice-weekly sessions (10am – 12pm) and at other times to regular users with access. Situated within an existing allotment compound, the site was surrounded by secure fencing and was not visible from the street. The perimeter of the site bordered a local school playing field and disused industrial units. The site is represented schematically and in its surrounding context in Figures 5.12 and 5.13.

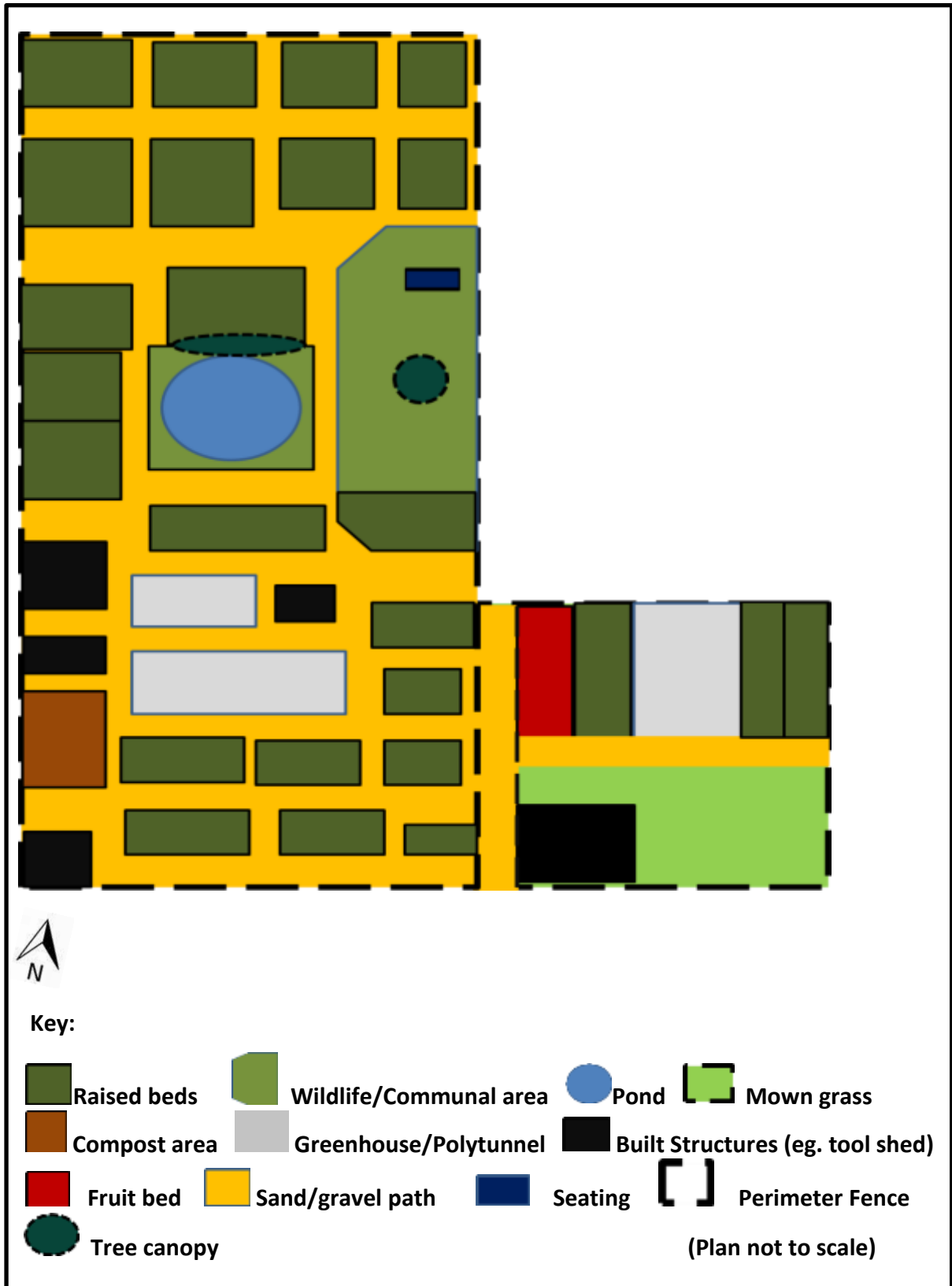


Figure 5.12 Planting and Learning Old Trafford (PLOT) schematic plan.





**Figure 5.13 Location of Planting and Learning Old Trafford (Google Earth, 2015).**

#### **Site 5. Moss Side Community Allotment (MSCA)**

MSCA was located in a residential area of Moss Side, Manchester, within a small council-owned allotment site. As well as vegetable beds, the site included a mini-orchard and chicken coup. Work days were organised twice-weekly (Saturdays and Sundays) though regular volunteers with access used the site during other times. The site was visible from the street but featured, as part of the existing allotment compound, secure perimeter fencing. The site is represented in a schematic diagram and is shown in the context of its surroundings in Figures 5.14 and 5.15 respectively.



Figure 5.14 Moss Side community allotment schematic plan.



**Figure 5.15 Location of Moss Side Community Allotment (Google Earth, 2015).**

**Site 6. Grow For It, Chorlton (GFIC).**

As with the other two case studies of this type, GFIC was located within an existing allotment site and as such was enclosed by secure perimeter fencing and access was limited. Again, as was the case for the two other community allotment sites, access was limited to two regular volunteer sessions which were run each week. The site was otherwise closed to the public. GFIC was visible from the street and was made more prominent by the use of road-side signage. The site layout is presented schematically in Figure 5.16 with site location detailed in Figure 5.17.

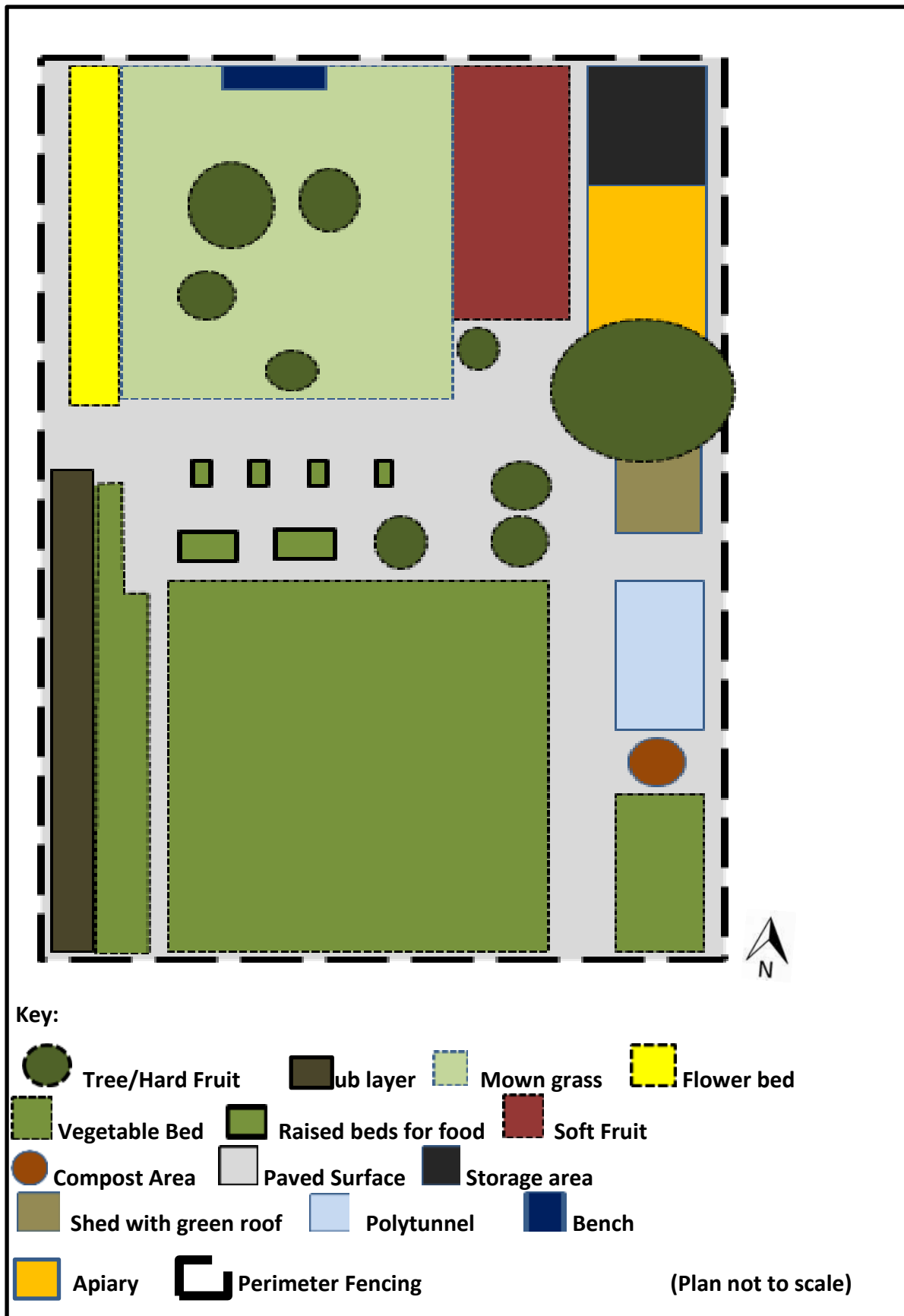


Figure 5.16 Grow For It Chorlton schematic plan.





**Figure 5.17. Location of "Grow For It", Chorlton (Google Earth, 2015).**

**i) Community orchards: Site 7. Stenner Lane Community Orchard (SLCO)**

SLCO was situated on land previously belonging to Didsbury Toc H Rugby Football Club in the Fletcher Moss area of Didsbury, a continuous area of green space consisting of parkland, botanical gardens, recreational land and local nature reserves. As such the site was situated in open green space with public access. Modification to the site was minimal and did not include any amenity or communal design features. The site was not visible from the street. The layout of the site is represented schematically in Figure 5.18 and site setting is shown in Figure 5.19.

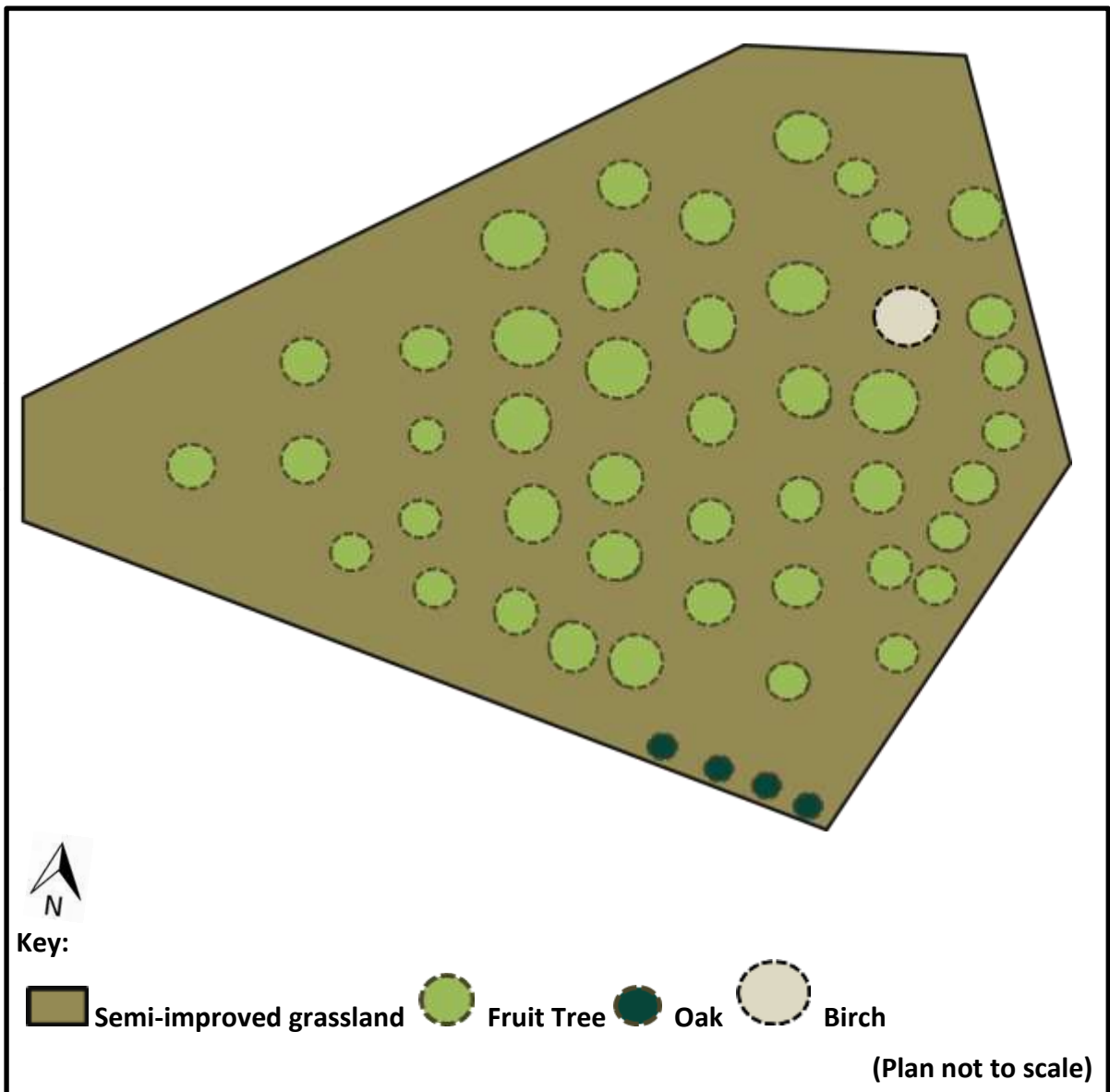


Figure 5.18 Stenner Lane community orchard schematic plan.



**Figure 5.19 Location of Stenner Lane Community Orchard (Google Earth, 2014).**

#### **Site 8. Birch Fields Forest Garden (BFFG)**

BFFG was a community-managed space within the ground of Birch Fields Park in South Manchester. Volunteers assembled at the site twice monthly for work days. The site was also managed periodically at other times by group members. Public access was available at all times and the site contained no amenity design elements, although the park in which it was situated featured seating and recreational facilities. The location of the site prevented it from being visible from the street. The design and location of BFFG is presented in Figures 5.20 and 5.21.

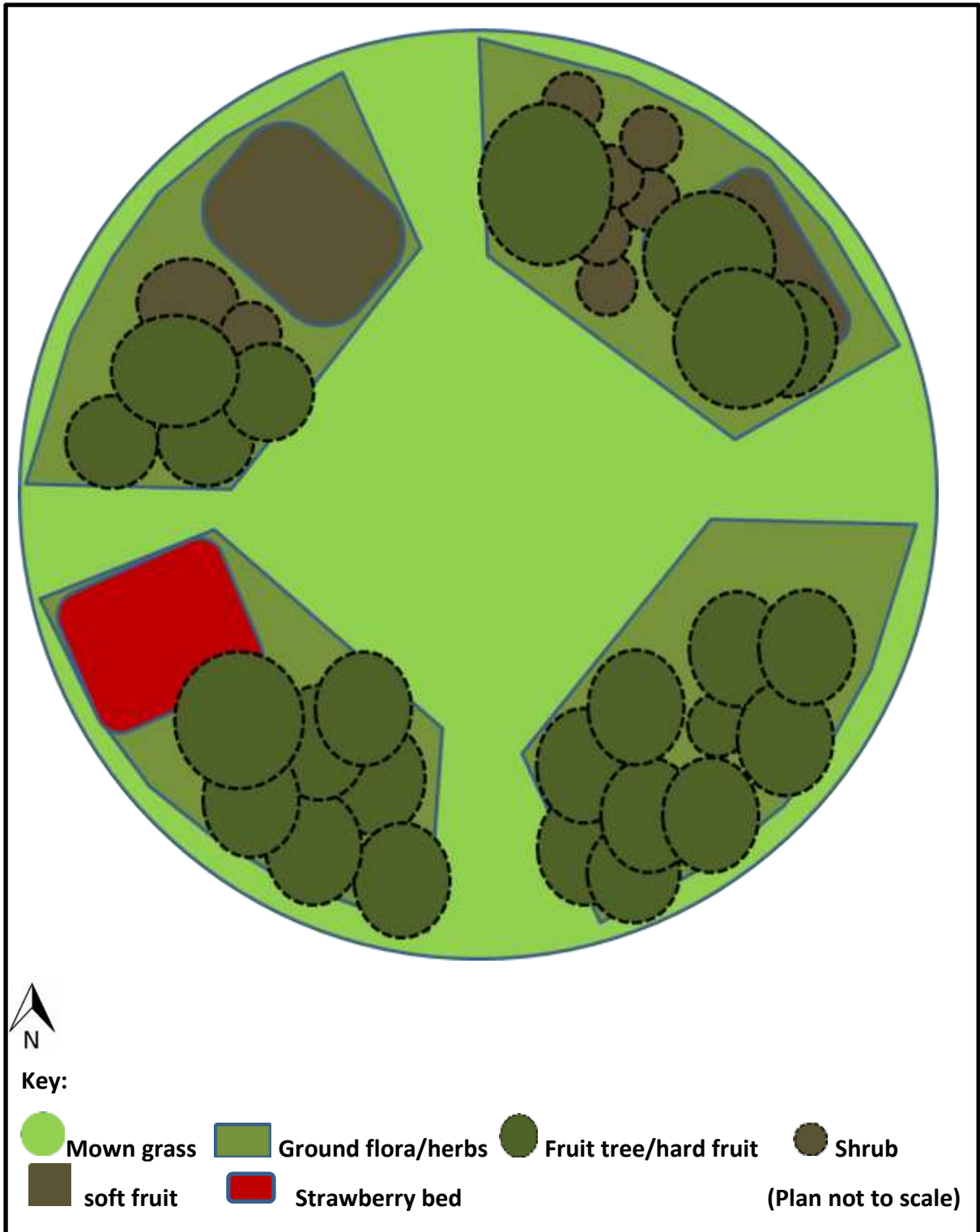
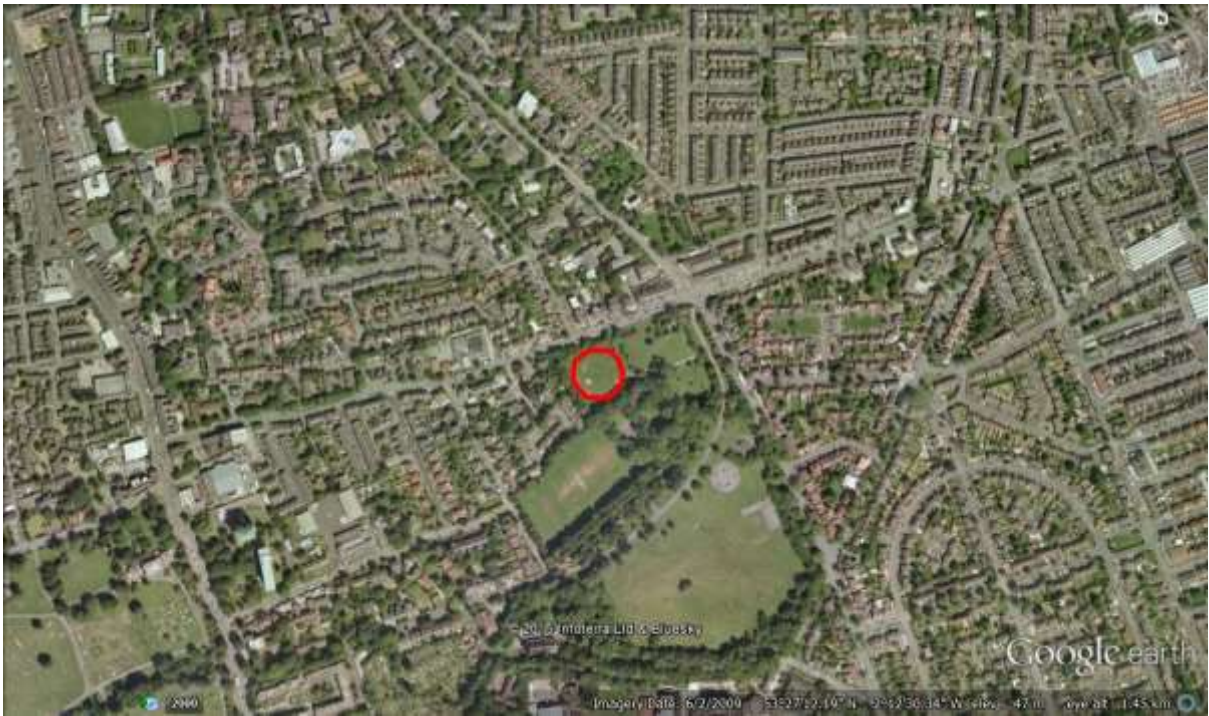


Figure 5.20. Birch Fields Forest Garden schematic plan.





**Figure 5.21 Location of Birch Fields Forest Garden (Google Earth, 2015).**

#### **Site 9. Philips Park Community Orchard (PPCO)**

PPCO was located on the edge of one of a large municipal park. The parkland also contained allotment gardens within which PPCO was situated. Accordingly the site was enclosed and, although the orchard was open to the public most days, the access was allowed only by admission through a secure entrance. PPCO was not visible from the street. The site layout and locality is presented in Figures 5.22 and 5.23.

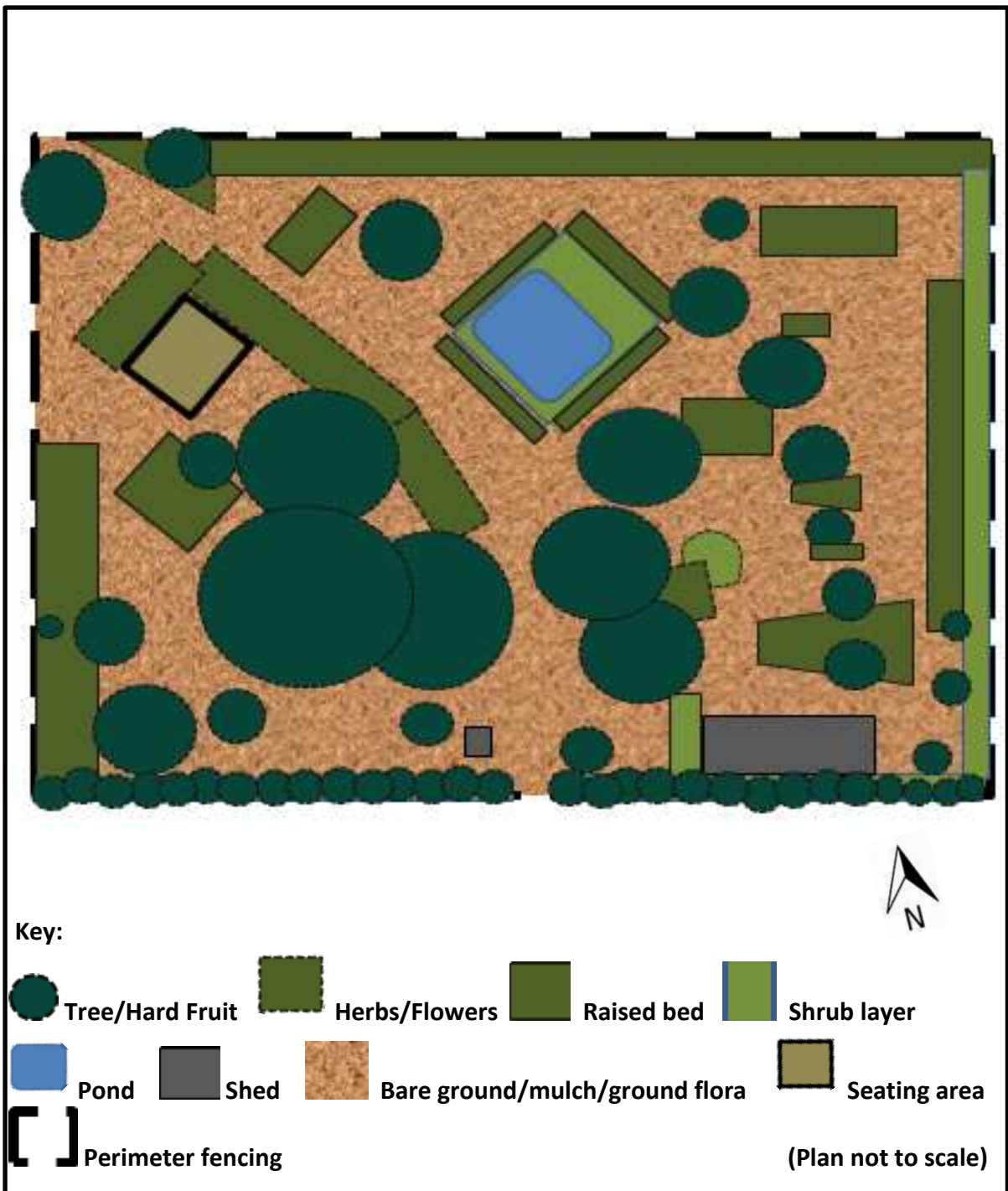


Figure 5.22 Philips Park community orchard schematic plan.



**Figure 5.23 Location of Philips Park Community Orchard (Google Earth, 2014).**

**iv) Pocket parks: Site 10. The Triangle**

The Triangle was situated in a pocket of disused communal land which previously contained domestic storage units. The site backed onto domestic residences and was accessible only through a secure gate. Through which The Triangle was visible from the adjoining street. The site was used by local residents and volunteer days and events were organised sporadically through the year. A plan of the site and location are presented in Figures 5.24 and 5.25.

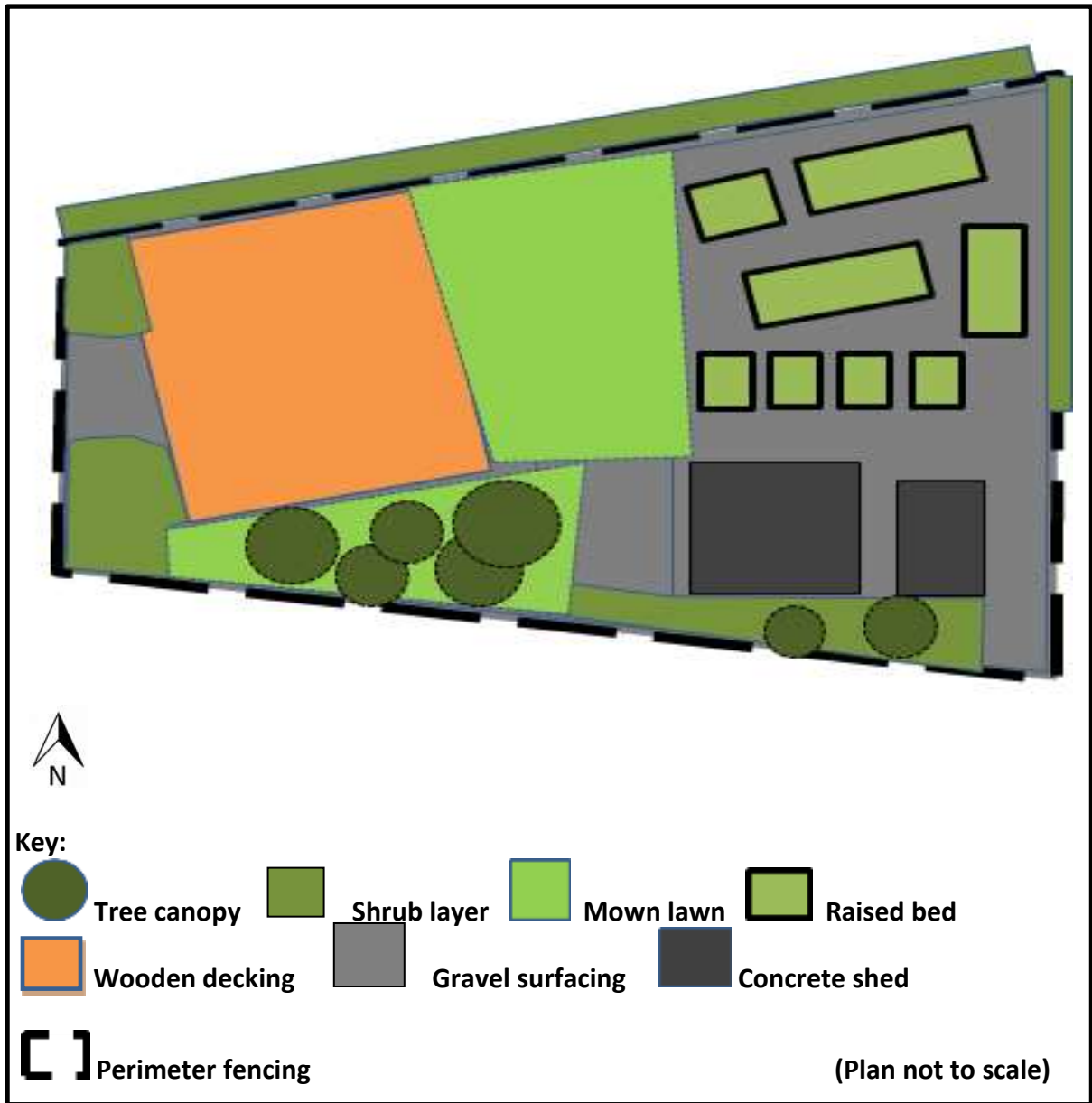


Figure 5.24 The Triangle schematic plan.





**Figure 5.25 Location of The Triangle (Google Earth, 2014).**

#### **Site 11. Dale Street Car Park**

The site on Dale Street Car Park was located in the Northern Quarter of Manchester city centre on an existing car park. The site consisted mainly of grow boxes, was visible from the street and publicly accessible at all times without any form of perimeter security. Site design was almost exclusively centred on food production and no space was designated for amenity design features. Volunteer work days and events at the site were organised albeit irregularly. A schematic site plan and map of surrounding area are presented in Figures 5.26 and 5.27.

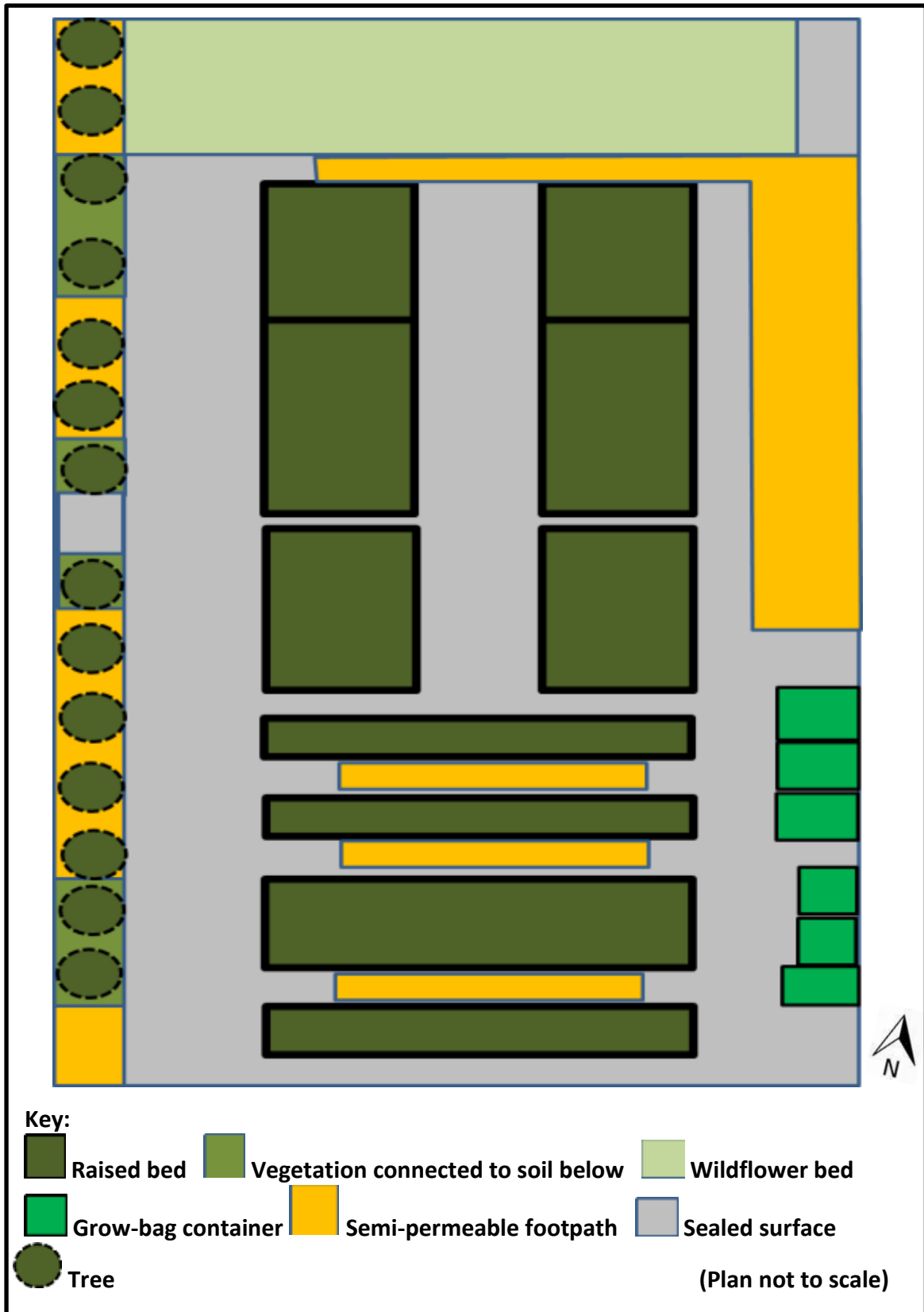
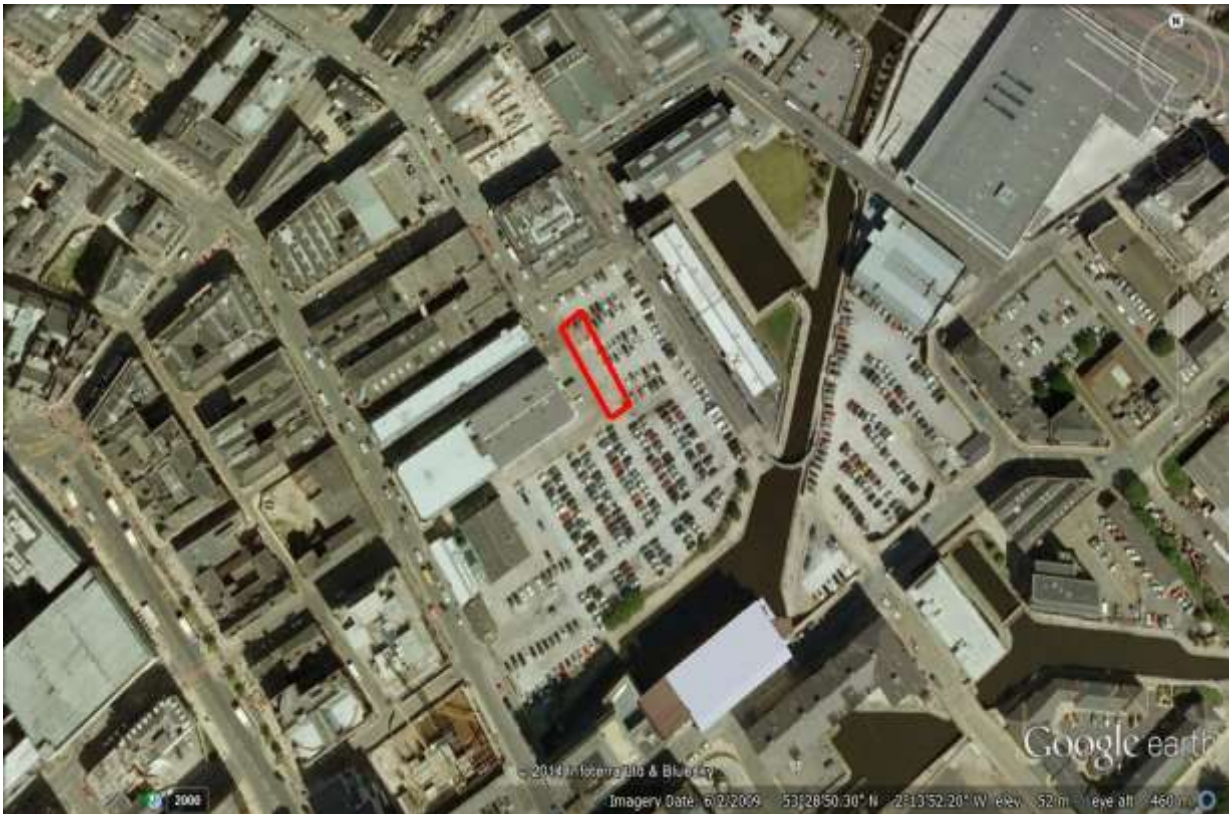


Figure 5.26. Dale Street car park site: schematic plan.



**Figure 5.27. Location of Dale Street car park (Google Earth, 2014).**

**Site 12. Hulme Community Garden Centre, Annexe (HCGC).**

The site at HCGC was the result of a development of land previously used as a car park and consisted of improvised grow boxes, raised beds and other styles of container planting.

Volunteers from the adjoining garden centre were involved in the on-going maintenance of the site to which public access was possible on a daily basis. However, the site was securely enclosed and access was subject to site opening hours (10am to 4pm). The site was visible from the street from all sides. A schematic plan and aerial view of the site are presented in Figures 5.28 and 5.29.

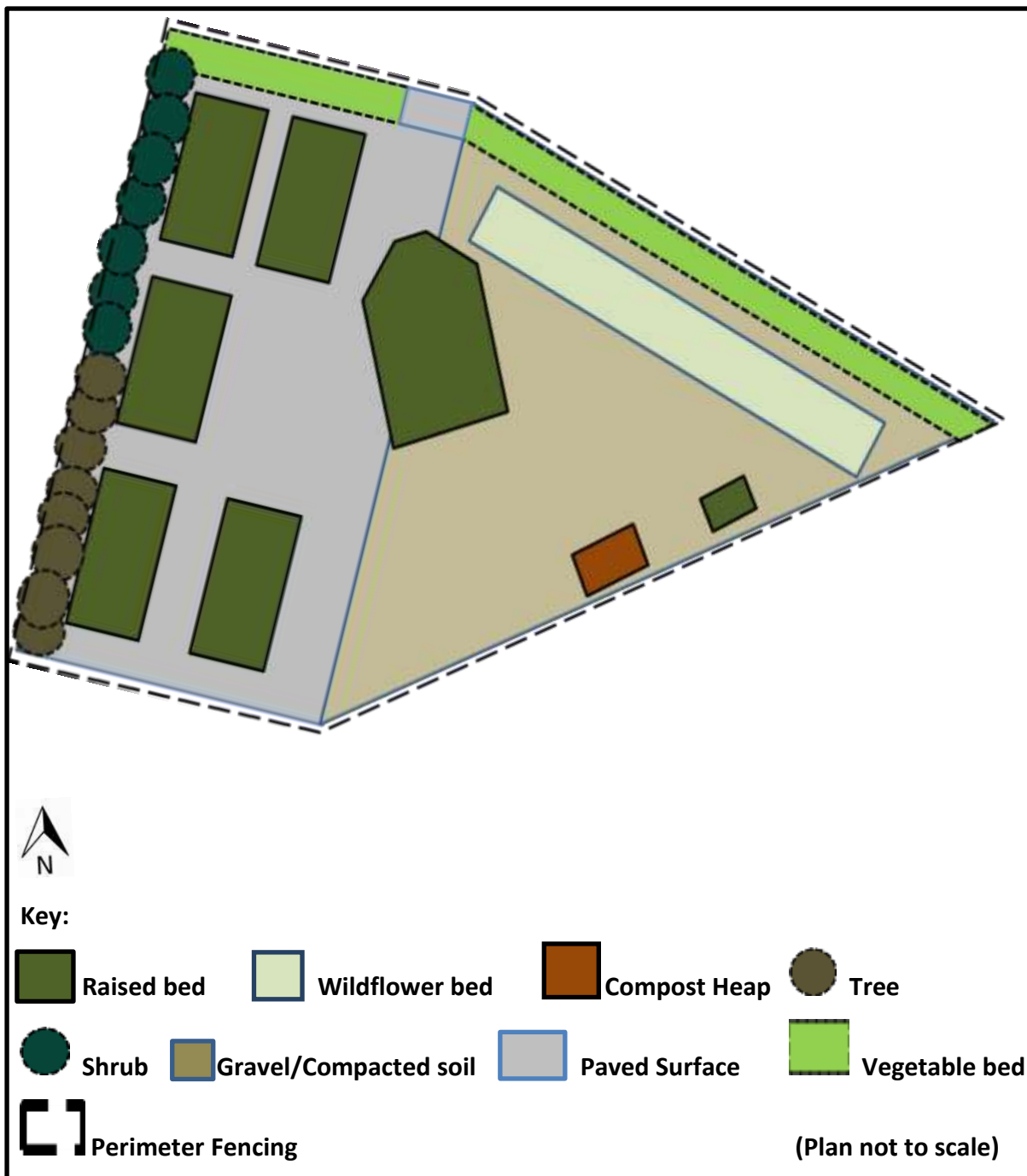


Figure 5.28 Hulme Community Garden Centre annexe: schematic plan.





**Figure 5.29 Location of Hulme Community Garden Centre annexe (Google Earth, 2015).**

Basic information on site access and setting which were gathered (as explained in Section 5.2.5) is summarised in Table 5.6.

**Table 5.6 Case study site access.**

Site	Visible from street	Access	Security/Fencing
Centenary	Yes	Public Access	Yes
FSG	No	Limited Access	Yes
BMRCG	No	Private	Yes
PLOT	No	Limited Access	Yes
MSCA	Yes	Limited Access	Yes
GFIC	Yes	Limited Access	Yes
SLCO	No	Public Access	No
BFFG	No	Public Access	No
PPCO	No	Limited Access	Yes
Triangle	Yes	Private	Yes
Dale St	Yes	Public Access	No
HCGC	Yes	Limited Access	Yes

**Type key:**

- community gardens
- community allotments
- community orchards
- pocket parks

**Site Key:**

**FSG = Fallowfield Secret Garden, BMRCG = Barlow Moor Road Community Garden, PLOT = Planting and Learning Old Trafford, MSCA = Moss Side Community Allotment, GFIC = Grow For It Chorlton, SLCO = Stenner Lane Community Orchard, BFFG = Birch Fields Forest Garden, PPCO = Philips Park Community Orchard, HCGC = Hulme Community Garden Centre.**

Site design across the case study sites exhibited considerable diversity. However, OSEI types were generally homogenous according to the description offered in the OSEI typology in Chapter 4. Commonalities in site layout and management as well as distinctive features of each are described according to the established typology.

**5.3.1.1 OSEI type descriptions: community gardens**

Of the four types of provisioning OSEI represented in the case-study quorum, community gardens displayed the greatest degree of heterogeneity in terms of individual site design as well as that between sites of the same type. Centenary Gardens and Fallowfield Secret Garden in particular contained an array of features and design elements such as walkways, raised beds, fire-pits, seating areas and rockeries as well as gazebos, roundhouses, sheds and other improvised built structures. On the other hand, Barlow Moor Road Community Garden

placed a greater emphasis on cultivation, primarily for food in terms of the approach to site management with very little sealing and no built structures incorporated into the design. The multiplicity of features present at these sites as well the variation within this type reflected the utility aspect of community gardens as well as the site-specific quality of their genesis. As such, discrepancies in site characteristics and management were shaped by a combination of community user preference, availability of resources and the pre-existing site conditions. This type of OSEI therefore exhibited a high degree of adaptability and presented a broad range of characteristics.

The degree to which sites of this type varied was also evident in terms of site size, with a relatively high co-efficient of variation of 0.40 (Table 5.5). In all cases, sites were the result of regeneration of previously DUN (derelict, unused and neglected) land via a collective effort by community stakeholders. Fallowfield Secret Garden resulted from the donation of derelict incidental green space by City South Housing Association to local residents. Similarly, the site of Barlow Moor Road Community Garden was a long-neglected patch of land handed over to local residents by a local social landlord and the redevelopment of disused land at Centenary Gardens was the result of a consultation between local residents, Seymour Park Primary School and Trafford Council. Initial landscaping and site preparation was contracted to the local environmental regeneration charity Groundwork Trafford, with continuing maintenance and site management undertaken by a committee of local residents supported by the adjacent school.

#### **5.3.1.2 Community allotments**

This type of OSEI was, of all those included in the case study, the most consistent and uniform in terms of site design. The primary features of such sites were a combination of raised beds, pathways (often consisting of sand/gravel or paving) and “wild” sections designated as areas for the promotion of wildlife. Community allotments, relative to sites of other types, uniformly contained an extensive built element comprised chiefly of storage areas, poly-tunnels, glass-houses and seating areas. The regularity exhibited in community allotment design appeared to be a direct result of their status as (new or previously developed) allotment sites. All three sites of this type represented in the case study were

either pre-existing allotment plots adopted by a community group or newly developed plots annexed to allotment sites.

As such, community allotments mimicked very closely the regular shape, accessibility and utilitarian elements which are common features of allotment plots in general. At community allotments the principal design imperative, in terms of site area designation, was the cultivation of food. In this respect these sites were highly homogeneous, in that they dedicated similar proportions of site area to cultivation, exhibiting the least degree of variation in percentage cover of cultivated surface. Community allotments did differ in other structural aspects, particularly, the extent of shrub and tree cover and the presence of structures employed in the keeping of livestock. The latter features were not present, for example, at the Planting and Learning Old Trafford (PLOT) site but at Moss Side Community Allotment (MSCA) and Grow For It, Chorlton (GFIC) site design incorporated features for the keeping of poultry for eggs and an apiary for the production of honey respectively (Figures 5.14 and 5.16). Similarly site structure at community allotments differed in the extent of tree canopy and shrub cover. Although vegetable cultivation appeared to be a consistent feature, soft and hard fruit production varied between sites. MSCA contained a relatively extensive canopy of non-edible, semi-mature remnant tree species with a small area designated to edible fruit trees, whereas GFIC site design incorporated a relatively extensive apple orchard combined with a lawn and seating area. Although accessibility was a design concern evidenced at each allotment site, with clear, maintained paths, the materials employed and degree of resulting surface sealing showed some variation according to site layout. Stone paving was a common feature of MSCA and GFIC, the latter employing such materials most extensively of the three sites. At PLOT, the use of sand and gravel was preferred to demarcate and support walkways. Water features were found at two of the three community allotment sites. In terms of location and overall site accessibility, all community allotment sites were securely enclosed and access was limited to designated opening hours and pre-determined work days. Two of the three were prominent in their immediate locality in that they were visible from street level with clear signage. All three community allotments in the case study were located in residential areas, on or in close proximity to existing allotment sites and were led by members of the community who were experienced allotment gardeners.

### **5.3.1.3 Community orchards**

Sites belonging to this type showed the greatest variation in total area with a co-efficient of variation of 0.53 for this characteristic. All three occurred at locations which consisted of expansive areas of public green space and all three were publicly accessible at all times and took the production of hard fruit as their staple design feature. However, notwithstanding these defining commonalities, community orchards displayed important variation in other areas of site design. As well as showing great variety in terms total site area, the three sites of this type also exhibited considerable diversity in land management. Specifically, Stenner Lane Community Orchard consisted of hard fruit tree species planted thinly on an area of early succession grassland with an otherwise minimal approach to cultivation. Birchfields Forest Garden employed a permaculture-based approach to fruit cultivation which attempted to mimic features of natural succession and stratification. The site was divided into “quadrants” around a central island of closely mown grass which contained a comparatively negligible degree of plant diversity. Thirdly, Philips Park Community Orchard exhibited a much greater degree of cultivation intensity which, although taking hard fruit production as a primary aim, and with an extensive canopy as a result, also incorporated vegetable growing beneath and between gaps in the tree canopy. This level of cultivation intensity, incorporating both orchard and vegetable garden styles may be a historically determined feature of the site which was located both on registered parkland but also annexed to an existing minor allotment garden site. The three sites in this category therefore exhibited a large degree of variety, specifically in terms of the approach taken to food cultivation. However, one overriding common characteristic of these types was the minimal degree of surface sealing with little or no paving or built structures included in their design. As such, community orchards constituted the most naturalistic approach to OSEI observed in the case study.

### **5.3.1.4 Pocket parks**

All examples of pocket parks appearing in the case study occurred on sites which were previously subject to total surface sealing by impervious materials. As such, all three sites of this type were necessarily the least naturalistic of all the case study sites and were distinct from the other nine cases which were developed on sites of pre-existing green space. Indeed, two of the sites in this category were found at locations which were formally

designated car parks. In terms of site setting, the case study pocket parks showed the greatest disparity of all four types, ranging from a city centre public parking zone, to suburban derelict land to a private, gated residential alleyway. The diversity in the physical context of pocket parks was a reflection of the high degree of improvisation that characterised this particular type of innovation and which also led to these being the most intensively designed. Being situated in areas with little or no existing vegetation or available substrate, site design was dependent to a large degree on container planting, raised beds, green façades and subject to very restricted levels of soil formation. However, as a result of their occurrence in areas of very poor ecological quality, pocket parks had, of those types of innovation defined in this thesis, the greatest potential in terms of contributing to the ecological intensification of sites.

On an organisational level sites demonstrated equally great variation in terms of their genesis and maintenance. The city centre park on Dale Street was one of several small sites maintained under the umbrella of the community-led neighbourhood project Northern Quarter Greening which itself grew out of the Manchester Garden City project. The site annexed to Hulme Community Garden Centre also grew out of a previous enterprise: a community garden centre with charitable status offering environmental educational opportunities and a leading provider of social prescribing in the local area. The Triangle was the result of the development of previously DUN communal space by the local Cranswick Square Residents Association and grew out of the social-ecological entrepreneurship of prominent community members.

A holistic approach to land cultivation was observed across case study sites and types. In all cases, horticultural practices followed closed-loop, organic gardening methods and permaculture design was also employed to varying degrees at all sites. In particular, Birchfields Forest Garden and Fallowfield Secret Garden adhered exclusively to permaculture principles.

### **5.3.2 Ecosystem services: microclimate regulation**

In order to explore the benefits of types of social-ecological innovation to urban microclimate regulation, a GI score was obtained by carrying out a modified version of the GI survey tool following the method outlined in Section 5.2.1. For the assessment undertaken,

any score over 0.6 achieves a “very good” rating in line with 2011 BREEAM guidelines as required by GI Northwest’s standards for new developments. The GI scores achieved by each site are detailed in table 5.7 (see Appendix 3 for full calculation steps of site GI scores).

**Table 5.7 GI score by type.**

Garden	GI Score	Type mean	Type cv
Centenary	0.71	0.85	0.16
FSG	0.86		
MRCG	0.99		
PLOT	0.74	0.73	0.08
MSCA	0.79		
GFIC	0.68		
SLCO	1.12	1.16	0.03
BFFG	1.14		
PPCO	1.20		
Triangle	0.62	0.56	0.14
Dale St	0.47		
HCGC	0.60		

Type key:

- community gardens
- community allotments
- community orchards
- pocket parks

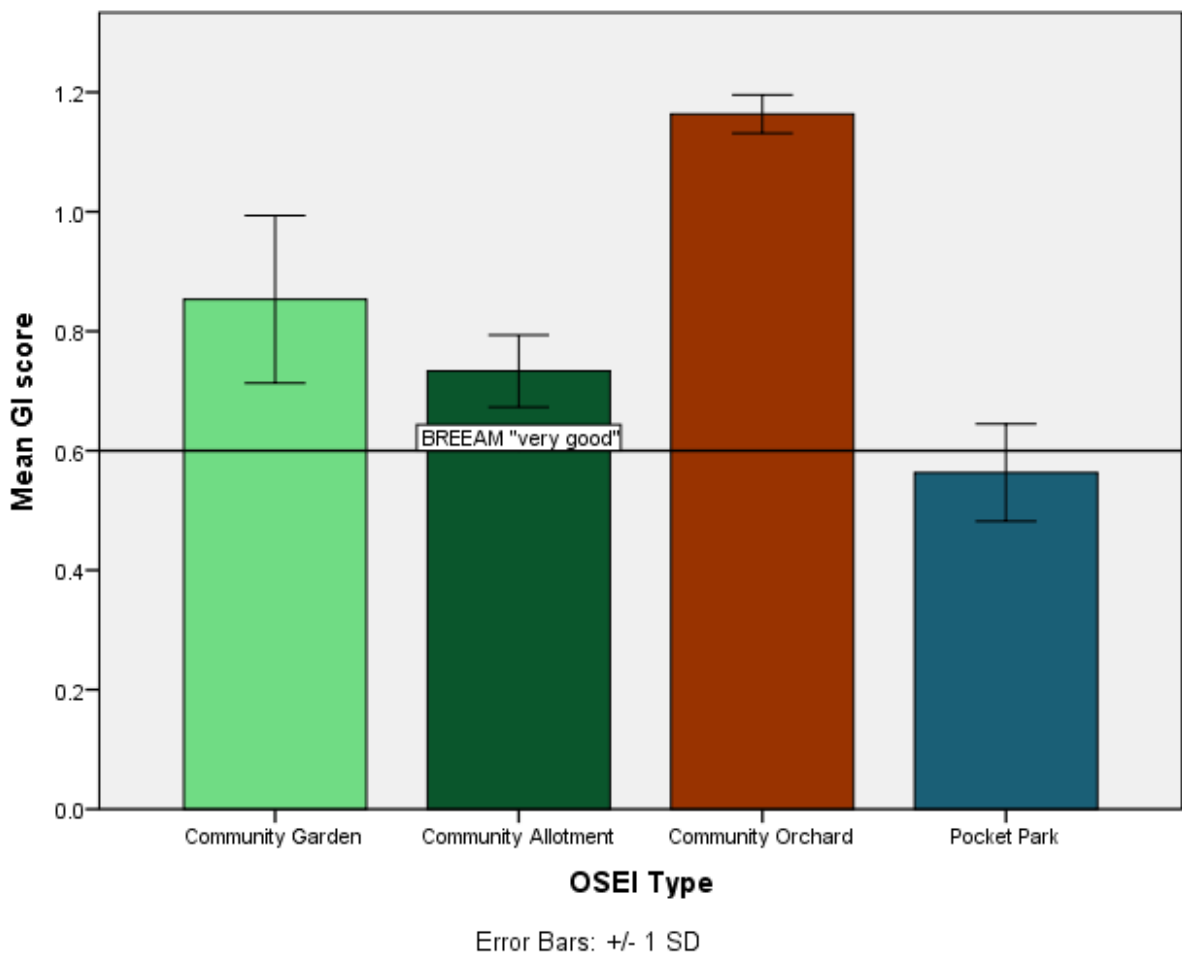
Mean = 0.83 ±0.24; cv = 0.29

Site Key:

FSG = Fallowfield Secret Garden, BMRCG = Barlow Moor Road Community Garden, PLOT = Planting and Learning Old Trafford, MSCA = Moss Side Community Allotment, GFIC = Grow For It Chorlton, SLCO = Stenner Lane Community Orchard, BFFG = Birch Fields Forest Garden, PPCO = Philips Park Community Orchard, HCGC = Hulme Community Garden Centre.

These data show that the mean score for the types community orchard and community garden both occurred above the mean for the sample, with community orchards scoring highest overall with a group mean of 1.16. The lowest mean score by type was for pocket parks at 0.56 which is below the minimum score required for BREEAM standard “very good”. However, of all twelve sites only one, Dale Street, scored individually below this standard. The type community garden showed the highest degree of variation between sites with a coefficient of variation of 0.16, with community orchards exhibiting the least. These data therefore suggest that variance between sites of the same type was much lower than that of

sites of different types. The coefficient of variation was calculated for the between sites, types and within type for GI scores and is used for analysis of variance across the four ecosystem services studied in this thesis. The reason for this being that it provided a dimensionless value which to be applied to all data sets regardless of scale or type. Community orchards scored consistently higher than other sites, were the only sites to score above 1.0 and their collective mean score was 0.21 higher than the next highest type, community gardens. Moreover, the highest type mean score was more than double that of the lowest. Figure 5.30 presents mean GI scores by OSEI type.



**Figure 5.30 Mean GI score by OSEI type. Mean = 0.83 ±0.25; cv = 0.31 (y axis reference line shows BREEAM “very good” standard).**

The types community garden (cv = 0.16) and pocket park (cv = 0.14) displayed the highest within-type variation, both exhibiting over four times the amount as can be seen for the lowest – community orchards (cv = 0.03) . Community allotments (cv = 0.08) as a group varied closer to the mean within-type cv of 0.10.



### 5.3.3 Food production

Data on total area under cultivation for production of fruit and vegetables were collected and transformed into values for estimated yield per site (Table 5.8). Details of the calculation steps employed in obtaining values for projected yield can be found in Appendix 5.

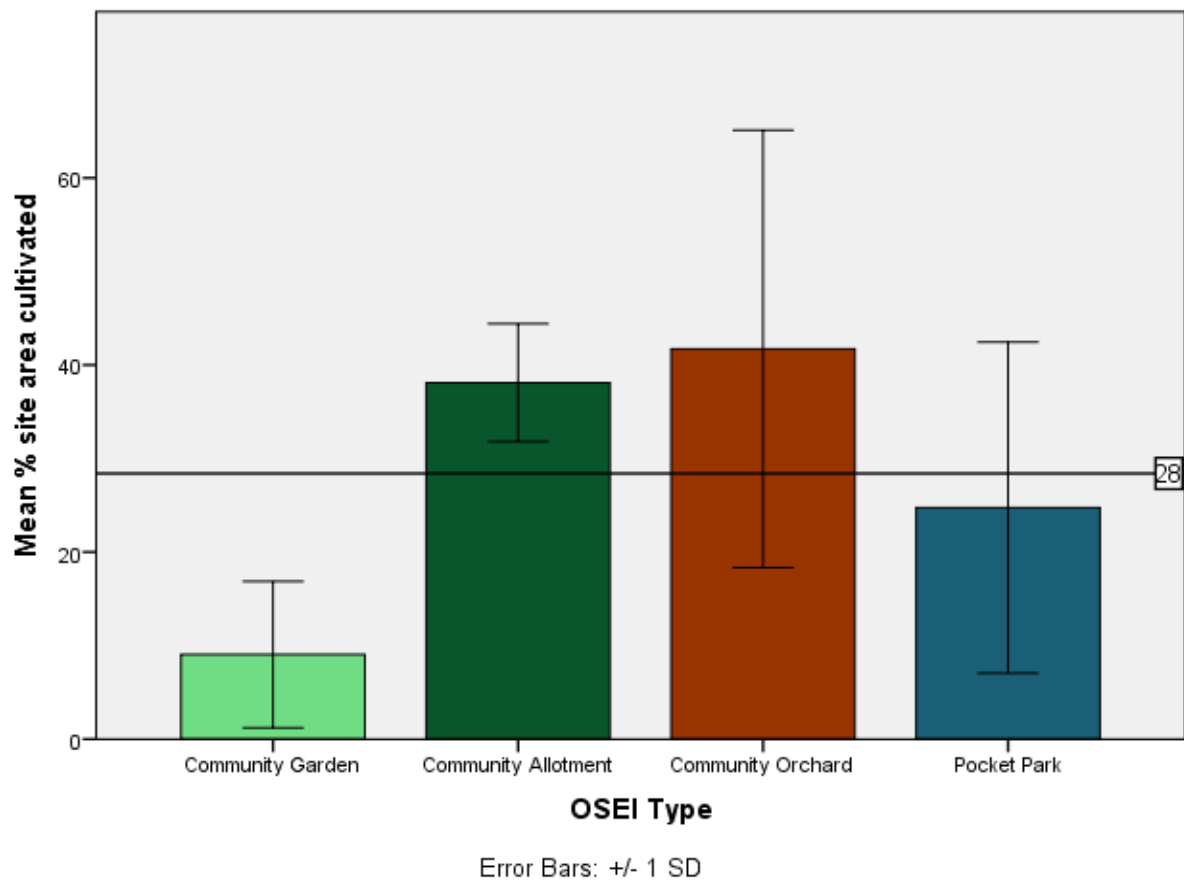
**Table 5.8 Food related practices and projected food yields.**

Site	Site Area (m <sup>2</sup> )	Cultivation Area (m <sup>2</sup> )	Percentage cultivation	Total Yield (kg)	Type key:
Centenery	936	36	4	129	community gardens
FSG	1530	80	5	555	community allotments
BMRCG	560	101	18	485	community orchards
PLOT	950	403	42	2502	pocket parks
MSCA	780	320	41	2110	
GFIC	630	195	31	1104	
SLCO	1044	260	25	390	
BFFG	1734	552	32	806	
PPCO	380	260	68	716	
Triangle	215	34	16	125	
Dale St.	221	100	45	608	
HCGC	217	29	13	199	

#### Site key:

FSG = Fallowfield Secret Garden, BMRCG = Barlow Moor Road Community Garden, PLOT = Planting and Learning Old Trafford, MSCA = Moss Side Community Allotment, GFIC = Grow For It Chorlton, SLCO = Stenner Lane Community Orchard, BFFG = Birch Fields Forest Garden, PPCO = Philips Park Community Orchard, HCGC = Hulme Community Garden Centre.

Type mean figures for total site area designated to food production are presented in figure 5.31.



**Figure 5.31 Mean extent of cultivation effort by type. Grand Mean = 28% ±19%; cv = 0.70.**

There was considerable variation in extent of food cultivation effort between sites with a standard deviation across all sites of 19% (cv = 0.70). Much of this variation is accounted for by the type community garden which itself exhibits a coefficient of variation of 0.86 in contrast to community allotments which exhibited a relatively little variation of percentage cultivation (cv = 0.16). Figure 5.31 shows the mean cover for community allotments and community orchards as being well above the grand mean percentage at almost 40%, although, in the case of community orchards, considerable variation was observed in food production effort at sites surveyed (cv = 0.61).

As can be seen in Table 5.8, considerable variation was observed for estimated food yield across the twelve case studies with an overall standard deviation of ±733kg for a mean value of 930 kg. This reflects the variance observed in cultivation extent in Figure 5.31. It was clear that cultivation extent varied between sites and that overall site area was a factor in projected yield. Therefore a further calculation was carried out to provide a projected measure of site productivity. By dividing the total yield by total site area a ratio was obtained

demonstrating yield in kilograms  $100\text{m}^{-2}$  for each site. The results of this calculation are presented in Table 5.9.

**Table 5.9 Yield per site as  $\text{kg } 100\text{m}^{-2}$ .**

Garden	Yield ( $\text{kg } 100\text{m}^{-2}$ cultivated area)	Yield ( $\text{kg } 100\text{m}^{-2}$ total site area)	Type mean (total site area)	Type cv
Centenary	358	14	46	0.82
FSG	694	36		
BMRCG	480	87		
PLOT	621	263	236	0.22
MSCA	659	271		
GFIC	566	175		
SLCO	150	37	91	0.93
BFFG	146	46		
PPCO	275	188		
Triangle	368	58	142	0.82
Dale St	608	275		
Hulme CGC	686	92		

**Type key:** Mean (for total site area) =  $129 \text{ kg } 100\text{m}^{-2} \pm 100 \text{ kg } 100\text{m}^{-2}$ ; cv = 0.78.

community gardens
community allotments
community orchards
pocket parks

**Site key:**  
 FSG = Fallowfield Secret Garden, BMRCG = Barlow Moor Road Community Garden, PLOT = Planting and Learning Old Trafford, MSCA = Moss Side Community Allotment, GFIC = Grow For It Chorlton, SLCO = Stenner Lane Community Orchard, BFFG = Birch Fields Forest garden, PPCO = Philips Park Community Orchard, Hulme CGC = Hulme Community Garden Centre.

As in the case of cultivation extent, there was considerable variation in site productivity. The standard deviation in this case was over three quarters the value of the mean, at  $100 \text{ kg } 100\text{m}^{-2}$  and  $129 \text{ kg } 100\text{m}^{-2}$ , respectively. The site with the highest projected yield per unit area was Dale Street with a value of  $275 \text{ kg } 100\text{m}^{-2}$  which was greater than the lowest (Centenary Gardens,  $14 \text{ kg } 100\text{m}^{-2}$ ) by a factor of almost 20. The data pointed to a considerable variation in emphasis on food production across the case study sites with a coefficient of variation of 0.78.

Community allotments showed markedly less variation in projected yield values per square metre than sites in the other case study types and, conversely, showed markedly greater yield estimates as a group. Mean productivity by OSEI type is presented in Figure 5.32.

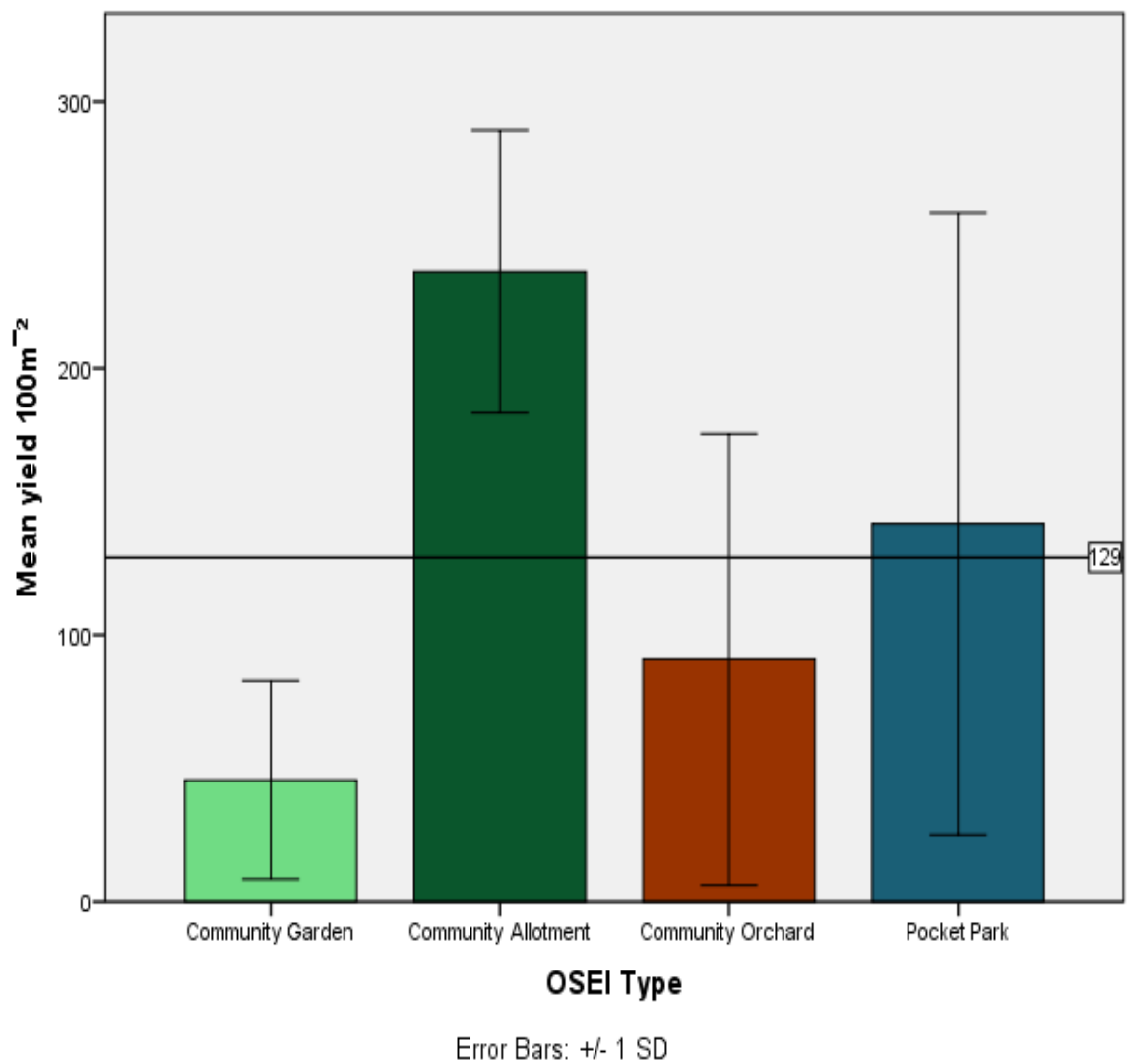


Figure 5. 32 Mean yield 100m by type. Grand mean = 129kg 100m 100kg 100m; cv = 0.78

### 5.3.4 Biodiversity potential

A biodiversity measure was obtained using a rapid assessment measure after Tzoulas and James (2010) to provide a surrogate score by which to evaluate site contribution to biodiversity potential as an ecosystem service (detailed in Section 5.2.3). Data for the original site assessments are included in Table 5.10.

**Table 5.10 Biodiversity assessment data.**

Site	Site Area (m <sup>2</sup> )	Biodiversity score	Domin score	Genera Vascular Plants
Centenary	936	20	6	84
FSG	1530	25	7	107
BMRCG	560	16	8	52
PLOT	950	27	8	110
MSCA	780	24	8	90
GFIC	630	23	7	96
PPCO	380	26	9	100
SLCO	1044	17	11	34
BFFG	1734	21	9	68
Triangle	215	13	3	60
Dale St.	221	16	5	65
HCGC	217	15	5	55

Mean = 20 ± 4.5; cv = 0.22

**Type key:**

community gardens

community allotments

community orchards

pocket parks

**Site Key:**

FSG = Fallowfield Secret Garden, BMRCG = Barlow Moor Road Community Garden, PLOT = Planting and Learning Old Trafford, MSCA = Moss Side Community Allotment, GFIC = Grow For It Chorlton, SLCO = Stenner Lane Community Orchard, BFFG = Birch Fields Forest Garden, PPCO = Philips Park Community Orchard, HCGC = Hulme Community Garden Centre.

Biodiversity scores varied from 13 at the lowest (site: Triangle) to a highest score of 27 (Planting and Learning Old Trafford). To give an indication of the relative performance of the case-study sites, the original assessment of Alexandra Park, a large urban park and site on

which the method was piloted (and located within the study area of this research thesis) provided a mean score of 10 across sample sites (Tzoulas and James, 2010).

Variance for biodiversity across all sites appeared lower than for GI and Yield with a cv of 0.22. The low variance and high modality of the data was of note considering that the method employed by the rapid assessment did not take site area into account and no effort was made to normalise for the considerable differences in site area during the data collection. In ecology the species-area curve predicts that, at local levels, number of species increases proportionally with area increase (Rice and Kelting, 1955). Although the urban environment can be said to be an artificial one to a considerable extent, and that species-area relationships will not behave in the same manner as in more natural habitats, data were standardised in keeping with the tenets of the GI toolkit as explained in Section 5.2.1. Calculating the scores for biodiversity as a ratio  $100\text{m}^{-2}$  gave a modified version of a genera richness score which added a vertical element to the measure by taking into account the structural diversity of each site. The resulting biodiversity-area ratio (BAR) scores are presented in Table 5.11.

**Table 5.11 Site biodiversity-area ratio scores.**

Site	Biodiversity-area ratio	Type mean	Type cv
Centenary	2.14	2.21	0.28
FSG	1.63		
BMRCG	2.86		
PLOT	2.84	3.19	0.13
MSCA	3.08		
GFIC	3.65		
SLCO	1.63	3.23	0.97
BFFG	1.21		
PPCO	6.84		
Triangle	6.05	6.37	0.09
Dale St	7.24		
HCGC	6.91		

Type key:

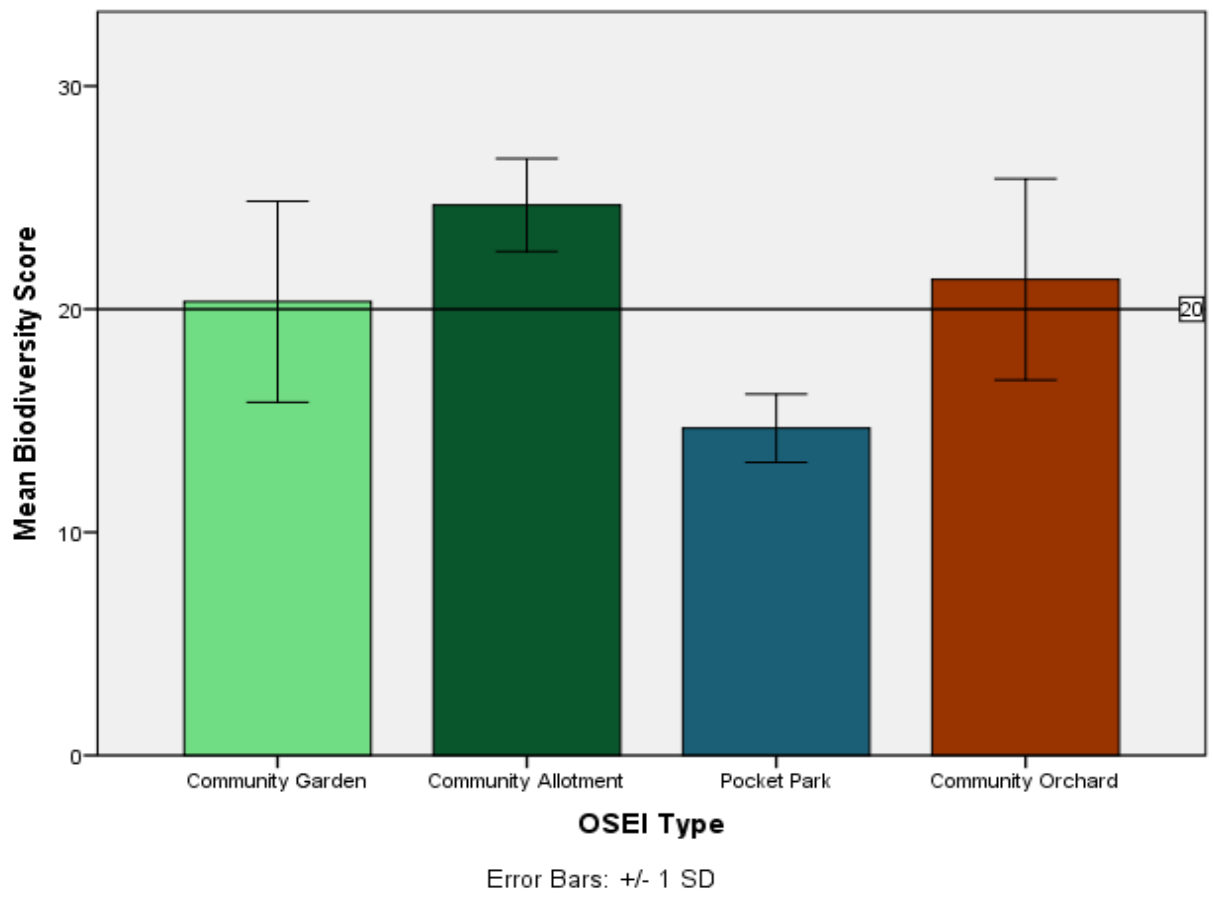
- community gardens
- community allotments
- community orchards
- pocket parks

Mean = 3.84 ±2.28; cv = 0.59

**Site Key:**

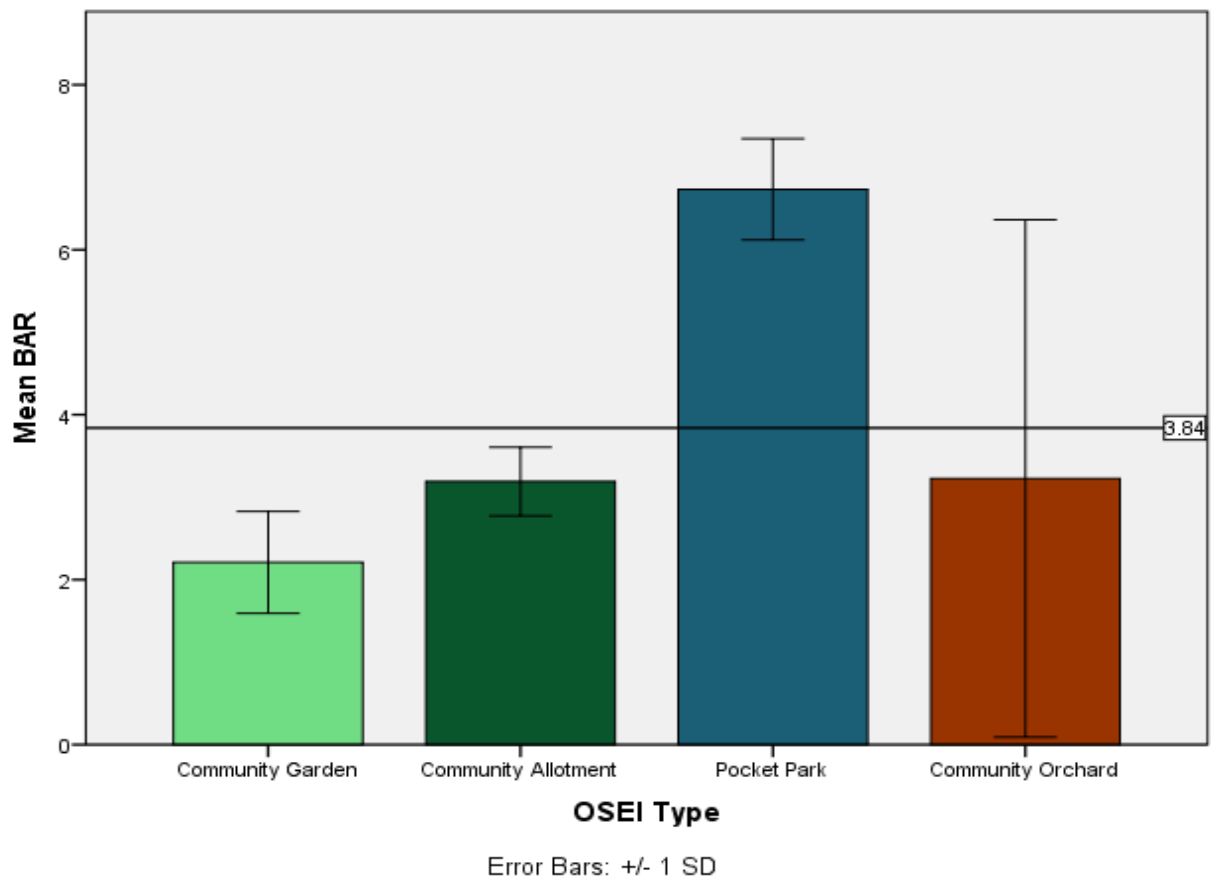
FSG = Fallowfield Secret Garden, BMRCG = Barlow Moor Road Community Garden, PLOT = Planting and Learning Old Trafford, MSCA = Moss Side Community Allotment, GFIC = Grow For It Chorlton, SLCO = Stenner Lane Community Orchard, BFFG = Birch Fields Forest Garden, PPCO = Philips Park Community Orchard, HCGC = Hulme Community Garden Centre.

The conversion of the biodiversity scores towards a measure of richness effectively placed greater emphasis on the variation between site characteristics in terms of richness of genera and structural diversity. Accordingly, the scores in table 5.11 show a coefficient of variation of 0.59 (as opposed to the coefficient of 0.22 in the original scores) perhaps as a reflection of high variation in site size. To demonstrate the effect on the relative standing of each type after the richness measure was applied to the results, a comparison of the original biodiversity score versus the richness measure is presented by type in Figures 5.33 and 5.34.



**Figure 5.33. Original biodiversity assessment scores: type means. Grand mean = 20 ± 4; cv = 0.22.**





**Figure 5.34. Type mean BAR (biodiversity-area ratio  $100\text{m}^{-2}$ ). Grand mean =  $3.84 \pm 2.28$ ;  $\text{cv} = 0.59$ .**

The data in Figures 5.33 and 5.34 show that, whereas community gardens, allotments, and orchards maintain their rank relative to each other, pocket parks move from lowest to highest in this version of the biodiversity evaluation. There was also much greater variance exhibited by the richness measure with a 0.59 (versus 0.22 of the original measure) coefficient of variation.

### 5.3.5 Education and well-being

In order to arrive at an appreciation of the cultural ecosystem services associated with each site, data were collected on volunteer hours and number of community events to gauge the level of community involvement as a surrogate for education and well-being as detailed in Section 5.2.5. A score was created which combined volunteer hours per month and events per year with equal weight. Scores for the resulting community benefit factor (CBF) are presented in Table 5.12.

**Table 5.12 Data related to education and well-being.**

Site	Volunteer		Final community benefit
	hours month <sup>-1</sup>	Events year <sup>-1</sup>	factor score
Centenary	40	200	240
FSG	288	12	300
BMRCG	200	2	202
PLOT	220	13	233
MSCA	300	48	348
GFIC	200	20	220
SLCO	20	3	23
BFFG	80	6	86
PPCO	152	12	164
Triangle	150	10	160
Dale St	44	2	46
HCGC	210	13	213

**Type Key:**

community gardens
community allotments
community orchards
pocket parks

**Site Key:**

**FSG = Fallowfield Secret Garden, BMRCG = Barlow Moor Road Community Garden, PLOT = Planting and Learning Old Trafford, MSCA = Moss Side Community Allotment, GFIC = Grow For It Chorlton, SLCO = Stenner Lane Community Orchard, BFFG = Birch Fields Forest Garden, PPCO = Philips Park Community Orchard, HCGC = Hulme Community Garden Centre.**

The resulting scores were satisfactory in reflecting the level of community participation at each site as a measure of community involvement and provision. The type which displayed the highest service provision in terms of community engagement was community allotments followed closely by community gardens. Community orchards showed the highest variation in CBF and scored lowest overall. There was considerable variation in data collected for number of volunteer hours associated with each site which was likewise reflected in number of events held at each site. Data on volunteer hours per month at sites which allowed free public access appeared to be lower than those where access was limited. Sites were grouped according to level of access (public, limited and private) and, based on these criteria, entered into a one-way ANOVA to compare mean volunteer hours per month. The ANOVA model

revealed significant group mean differences ( $F(2) = 18.43$ ;  $p = 0.001$ ), with post-hoc testing (Games-Howell) showing significantly lower mean values for sites with public access compared with those where access was limited (mean difference =  $181 \pm 81$  hours month<sup>-1</sup>;  $p = 0.001$ ). Sites providing limited access likewise scored highest overall for the case study in terms of volunteer hours month<sup>-1</sup> (mean =  $227 \pm 57$ ).

Although community engagement is dependent on a variety of social factors and not as obviously spatially dependent as other environmental phenomena such as species distribution or crop yield, the above scores were standardised for site area on the same principle as was employed for obtaining scores for GI, Yield and Biodiversity in order to maintain consistency within the data analysis. The results for the CBF score were adjusted as in the case of the three previous services above by creating a ratio of the service score 100m<sup>-2</sup>. The results are presented in Table 5.13.

**Table 5.13 Site community benefit factor (CBF) scores 100m<sup>-2</sup>.**

Site	Community benefit factor score 100m <sup>-2</sup>	Type mean	Type cv
Centenary	25.64	27.11	0.31
FSG	19.61		
BMRCG	36.07		
PLOT	24.53	34.69	0.29
MSCA	44.62		
GFIC	34.92		
SLCO	2.20	16.77	1.36
BFFG	4.96		
PPCO	43.16		
Triangle	74.42	64.46	0.61
Dale St	20.81		
HCGC	98.16		

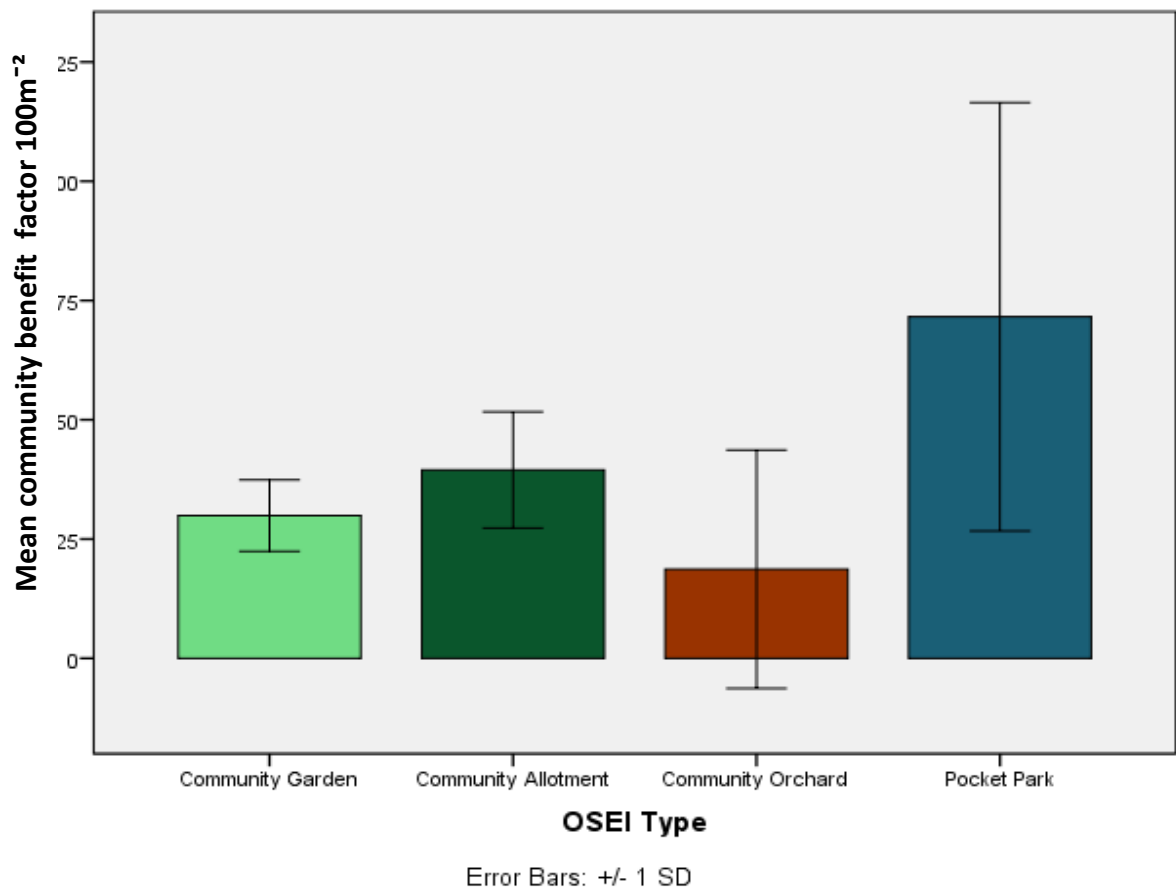
**Type key:**  
 community gardens  
 community allotments  
 community orchards  
 pocket parks

**Mean= 35.76 ±27.49; cv = 0.77**

**Site key:**

**FSG = Fallowfield Secret Garden, BMRCG = Barlow Moor Road Community Garden, PLOT = Planting and Learning Old Trafford, MSCA = Moss Side Community Allotment, GFIC = Grow For It Chorlton, SLCO = Stenner Lane Community Orchard, BFFG = Birch Fields Forest Garden, PPCO = Philips Park Community Orchard, HCGC = Hulme Community Garden Centre.**

The scores for CBF service, when standardised for site area, show a significant increase in variation from the original CBF scores with a coefficient of variation of 0.77. Figure 5.35 shows how types performed overall in this evaluation of the results for CBF.



**Figure 5.35 Community benefit factor 100m<sup>-2</sup>: type means. Grand mean = 35.76 100m<sup>-2</sup> ±27.49; cv = 0.77.**

As can be seen in Figure 5.35, pocket parks scored highest in terms of community benefit measured 100m<sup>-2</sup>, over three times higher than the lowest, Community Orchards. However, these two types exhibited much higher within-type variance than the other two case study types.

The extent of the variation in productivity per unit area by sites of the same OSEI type, along with a measure of the equality in provision across services by each site were calculated for comparison and are displayed in Tables 5.14 and 5.15 respectively. The co-efficient of variation in the percentage contributions of site ecosystem service scores (per unit area) to the case study total was used as a measure of equality of service provision where a lower co-efficient of variation indicated a more even spread of provision across the four services in the assessment.

**Table 5.14 Summary of variance in service assessment scores (as co-efficient of variation).**

	Microclimate regulation	Yield	Biodiversity potential	Education/wellbeing	Type Mean
Community gardens	0.16	0.82	0.28	0.31	0.39
Community allotments	0.08	0.22	0.13	0.29	0.18
Community orchards	0.03	0.93	0.97	1.36	0.82
Pocket parks	0.14	0.82	0.09	0.61	0.42
Case study overall	0.29	0.78	0.59	0.77	
Within-type mean	0.10	0.70	0.37	0.64	

As demonstrated in Table 5.14, for each of the ecosystem service assessments, the mean within-type variation was significantly lower than that for the case study overall which lent satisfactory credence to the validity of the typology and site selection employed in the study.

**Table 5.15 Equality in service provision (expressed as co-efficient of variation (cv), where a lower cv indicates greater evenness in provision across services).**

Site	cv of service contributions	Type Mean
Centenery	0.58	0.47
FSG	0.57	
BMRCG	0.27	
PLOT	0.59	0.43
MSCA	0.46	
CCA	0.23	
SLCO	1.08	0.75
BFFG	1.03	
PPCO	0.16	
Triangle	0.62	0.64
Dale St	0.65	
HCGC	0.65	

**Type key:**

- community gardens
- community allotments
- community orchards
- pocket parks

**Site key:**

**FSG = Fallowfield Secret Garden, BMRCG = Barlow Moor Road Community Garden, PLOT = Planting and Learning Old Trafford, MSCA = Moss Side Community Allotment, GFIC = Grow For It Chorlton, SLCO = Stenner Lane Community Orchard, BFFG = Birch Fields Forest Garden, PPCO = Philips Parks Community Orchard, HCGC = Hulme Community Garden Centre.**

## 5.4 Discussion

The results as they have been presented so far have been treated in turn according to individual ecosystem services. The initial discussion of these results will continue in this vein evaluating elements of site design and setting which provide the context of ecosystem services provision. Chapter 6 includes further statistical analyses and discussion which focusses on trade-offs and synergies across ecosystem services, site characteristics and types of innovation.

### 5.4.1 Microclimate regulation

The tool employed to evaluate microclimate regulation by each site is based on the concept of *ecological effectiveness* which is essentially a measure of the total surface cover, at a given site, by different vegetative structures which reflect various levels of succession. The tool is modified for the urban environment to include artificial surfaces in combination with “green” elements. As such, sites with a higher percentage of vegetated surface cover would be expected to generally score higher than those whose ecological functioning is hampered by sealed and other artificial land cover types.

This expectation is generally fulfilled in the results presented in Section 5.3.2 (Table 5.7). The two types of OSEI exhibiting the greatest disparity in terms of vegetative surface cover, likewise exhibited the greatest difference in the resulting GI score. Community orchards, of all the sites studied, were subject to the lowest degree of surface sealing (mean GI score = 1.16, Table 5.7) with pocket parks localities exhibiting the highest (mean GI score = 0.56, Table 5.7). Community gardens and allotments scored second and third highest overall and again this reflects the level of surface sealing observed at these sites. Community orchards, of all sites, were those whose management was the least intensive (Section 5.3.1) and this was the significant characteristic which leads to such sites showing the highest extent of vegetation. Such sites tended to be focussed on a minimum maintenance approach and on productivity, as opposed to utility and communal use (Figures 5.18, 5.20 and 5.22). Conversely, community allotments tended to feature more intensive modification and, as a result, were managed more intensively, with communal, utility elements such as rest/eating areas. Consequently, at such sites access was a more pertinent issue and resulted in the use

of artificial elements such as stone flagging, built structures and fencing (Figures 5.12, 5.14 and 5.16) which will necessarily decrease the extent of the ecologically effective area of a given site. That said, the design of case study sites, as well as levels of maintenance varied widely and a variety of approaches was observed (Figures 5.6 to 5.29). This was evident particularly in the case of community gardens for which a standard approach was not recognised in the process of collecting data and surveying. Community gardens are, as the term suggests, a product of a given community and as such were designed to meet the needs and tastes of that community. It may be due to this characteristic that community gardens showed the greatest variation of GI score compared to other types (Table 5.7). For this reason, certain community allotments achieved a higher GI score than community gardens and vice-versa. On the whole, though, community gardens exhibited a higher mean score which suggested that an emphasis on food (found particularly in community allotments) presented a management imperative requiring more intensive site modification, often, although not necessarily, through the use of artificial structures (as documented in Figures 5.12, 5.14 and 5.16).

In the case of pocket parks, the premise of high sealing leading to low GI score holds but it was of interest that the genesis of such sites tended to develop from the opposite direction, ecologically speaking, than the other three categories in this report. Specifically, such sites of ecological innovation began from the starting point of highly urbanised, sealed surfaces and attempted to “green” such areas as far as possible. In such a case, whether certain sites appear as they do due to design, necessity or resource limitation is hard to say. What is certain is that with the initial presence of high levels of sealing, such sites are at a disadvantage in terms of achieving optimal GI scores and that as a result, comprise some of the most highly adapted, innovative sites in terms of design and management. For this reason, pocket parks also exhibit an above-mean level of variation in GI score reflecting the variety of design approaches. Clearly, there was a historical element which influenced the design of community allotments in particular, which were generally annexed to or contained within existing allotment sites with pre-existing, allocated plot dimensions. The ecological and cultural context of such sites therefore explains the observed homogeneity in design and management. Conversely, pocket parks, by their nature were situated on incidental pockets of land (Figures 5.25, 5.27 and 5.29) and therefore highly improvised and diverse in design (Figures 5.24, 5.26 and 5.28). This question of sealing and management intensity



seems, at first glance, to have implicit associations with human input and community involvement. This relationship is explored further in Chapter 6.

#### **5.4.2 Food production**

Of all the ecosystem services studied, data relating to the production of food showed the greatest level of variation across sites. That said, Community Allotments exhibited by far the least degree of variation whilst, at the same time, contributing over half of the total yield of all sites studied. Community Allotments also scored consistently above the mean in terms of productivity ( $\text{kg } 100\text{m}^{-2}$ : Table 5.9). This came as no surprise given that the main function of allotments of any kind is to produce fruit and vegetables for consumption, a fact reflected in the data relating to percentage site cultivation (Table 5.8). Each community allotment scored above the mean in this regard with all sites designating over a thirty percent of the total site area to food cultivation. Overall, community allotments and orchards exhibited similar type means for percentage site cultivation (Figure 5.31), but this figure is distorted by the fact that one orchard site in particular (Philips Park Community Orchard) scored significantly higher than the two other sites of this type (Table 5.8).

Again this demonstrates the variety of management practices that can be observed across sites within the same category, that is to say that intensification of a particular output varied dramatically. This distortion of the mean by an anomalous score coupled with the fact that two of the orchards were considerably larger than all but one of the other case study sites (Table 5.5) gave the impression that community orchards are very effective in delivering provisioning ecosystem services. Although, in terms of total yield, orchards provided considerable yields, second only to community allotments (Table 5.8), they scored equal with the mean for yield  $100\text{m}^{-2}$  – third highest behind allotments and pocket parks (Figure 5.32). This was the case despite the fact that orchards exhibited the greatest site cultivation extent overall (Figure 5.31) suggesting that a major factor contributing to the difference in productivity across sites was crop type as well as cultivation intensity. In other words, sites where the cultivation of vegetables took precedence over fruit tended to see greater yields as a result. It must be noted, however, that yields and analysis of productivity were projections based on previous research and accurate figures were not obtained directly from the growers. As such, the method used did not take into account variables such as

agricultural techniques, soil quality, horticultural competency or crop variety. In-depth harvest reports working with growers on-site to weigh and record total crop yield would provide better insight into actual site productivity.

According to the data (Table 5.9) pocket parks produced more food per square metre than community orchards and more than community gardens by a factor of three. This suggested that where space and access to good quality soil was an issue, as in the case of pocket parks, the tendency was for horticultural activities to be concentrated on food production rather than on ornamental gardening or the designation of utility spaces. The reasons for this may be socio-economic or a result of horticultural resources and ability. Conversely, in the case of community gardens, less emphasis was placed on production of food and a greater importance given to the provision of communal, utility design features (Figures 5.6, 5.8 and 5.10).

### **5.4.3 Biodiversity potential**

Biodiversity scores across all sites, upon preliminary analysis of the results, showed a low degree of variation ( $cv = 0.22$ ; Table 5.10) but the standardisation of the data by site area as a measure of richness demonstrated that sites varied considerably with the co-efficient of variation almost tripling. The reading of the biodiversity scores in terms of richness allowed for an appreciation of the contribution of each site to this ecosystem service terms of provision per site area. That is to say that, smaller sites which achieve a comparable biodiversity score to much larger sites are, in practice, providing more effectively in terms of biodiversity as a “service”. This observation is particularly salient given that urban areas, with high levels of disturbance and lack of quality natural spaces, are an unlikely haven for wildlife and so the optimisation of limited, existing green space in such an environment is of great importance.

The data in Section 5.3.4 of this chapter show that the type consisting of the smallest sites on average by area (i.e. pocket parks) exhibited the highest degree of richness overall in terms of biodiversity. Again, it would seem that the range which can be observed in the extent of provision of this service was down to a question of management. That the type of OSEI with the largest mean area (community orchards) scored well below the mean score for

biodiversity-area ratio would suggest that certain elements of site maintenance, as well as size, resulted in a limiting effect on biodiversity potential.

As presented in Section 5.3.1, community orchards tended to be managed with the least intensity and were generally more vegetated with fewer artificial elements (Figures 5.18, 5.20 and 5.22). However, it did not follow that such sites, as a result, contained greater vascular plant diversity. Although these sites were highly vegetated, which contributed to a high GI score (table 5.7), such sites also (with the exception of Philips Park Orchard) were quite homogenous in design (Figures 5.18 and 5. 20). In the case of Birch Fields Forest Garden, this homogeneity was due to an intensive mowing regime applied to a large area of the site – a result of the site being located in an area managed by Manchester City Council (Section 5.3.1). Similarly, Stenner Lane Community Orchard was located on the edge of recreation land with a pre-existing mowing regime (Section 5.3.1, Figures 5.18 and 5.19) and the site, is for the most part, situated on early succession grassland with limited heterogeneity. In the case of Philips Park Orchard, as alluded to in the discussion on provisioning services, the management regime was of a more intense nature with a higher rate of horticultural intervention (Figure 5.22).

As a result the site enjoyed a much higher degree of heterogeneity and biological richness (Section 5.3.4, Table 5.11). It is this element of human input, of horticultural effort creating a bio-diverse area which gave this site a biodiversity-area ratio which was larger, by a factor four, than the other two sites of its type. This observed influence of site management intensity on biodiversity holds true for the study as a whole. Those sites which were subject to the highest degree of management intensity (Section 5.3.1) generally scored highest in terms of biodiversity potential (Section 5.3.4). Community allotments on the whole exhibited a more intensive management approach than did community gardens and orchards (Figures 5.6 to 5.16; Table 5.7 and 5.8) which resulted in greater disturbance and sealing. However allotments scored higher overall than both community gardens and orchards for biodiversity potential. This begs the counter-intuitive conclusion that those sites with the greater amount of “built” (artificial) elements actually scored highest in terms of biodiversity potential. This is borne out by the fact that the OSEI type with by far the greater extent of surface sealing and the lowest mean GI score (pocket parks, Table 5.7), performed best in terms of biodiversity-area ratio. The mean biodiversity-area ratio score for pocket parks was nearly twice that of the second highest type mean (Table 5.11).

This conclusion appears to be paradoxical. From a conventional ecological point of view, one would expect areas with high levels of urbanisation (surface sealing) and human disturbance to have lower biodiversity potential (Marzluff, 2008; Chase and Walsh, 2006; Pauchard et al., 2006) but the data from this study seem to be demonstrating the opposite effect. Here, *within* the urban environment, an increase in human environmental management resulted in increased biodiversity potential. Although links have been asserted between an increase in plant species richness along an urbanisation gradient from rural to moderately urban (McKinney, 2008), previous studies have continuously highlighted the deleterious effect on high levels of urbanisation on biodiversity (Thompson et al., 2003; Zerbe et al., 2003; Kim and Pauleit, 2005; McKinney, 2008), but such evaluations have not paid sufficient attention to the improvised management of small parcels of green space in highly urbanised areas as exemplified by pocket parks. However, certain caveats should be stated here. It should be noted that the rapid assessment employed in the data collection was based solely on vegetative structure and diversity as a surrogate for biodiversity in general (Section 5.2.3). No consideration of other ecological characteristics, such as habitat size, connectivity, species type or substrate formation, were given consideration and the tool did not attempt to measure other classes such as mammals, birds or invertebrates. Furthermore, native and non-native vascular plant species were considered equally in this assessment of biodiversity. That said, the assessment scores stand alone and point towards the value of human innovation in the urban ecological landscape. Looking at the data, the inference is that, whereas the human influence on the natural environment is often a harmful one, and historically this has been undeniably so in terms of habitat and biodiversity loss, significant improvements can be made at the local scale by informal, chiefly horticultural community interventions. Such an inference would tend to suggest, quite hopefully, that humans, as environment engineers have the power to ameliorate, if not create, ecological integrity. The outputs of OSEI are particularly unique in this respect, especially in the case of highly innovative approaches to “greening” as exemplified by pocket parks. In such cases, where sites often start from a condition of total surface sealing (Section 5.3.1), improvised vegetated structures (Figures 5.24 , 5.26 and 5.28) served to increase the ecological effective area from effectively zero, to viable levels of both ecological function and biological richness (Tables 5.7 and 5.11).

#### 5.4.4 Education and well-being

The sites which performed most consistently well in terms of provision of education and well-being were of the types: community gardens and community allotments. These two exhibited markedly less variation in Community Benefit Factor (CBF) scores than did the other two types. In the case of both pocket parks and community orchards one site within each type scored considerably higher than the other two, without which the type mean score would have been dramatically reduced. Several reasons can be postulated for this high degree of variation in the latter two types and the resulting low mean score in terms of CBF. A crucial factor in the scoring of the CBF was a measure of community involvement through volunteering effort (hours month<sup>-1</sup> – Section 5.2.4). It was primarily the high levels of variation thereof which resulted in overall variance in terms of the final scores (Table 5.12). What might be the causes of such variation? Generally, it might be expected that more established sites with recognisable, established practices would attract a more consistent membership. This may be one reason why community gardens and allotments achieved higher CBF scores than the other two types. That is to say that, in the study area and throughout the UK in general, community gardening has a long history stretching back, in recent history to the Second World War and, as a contemporary movement, to the late 1960s. In terms of allotment gardening, the inception of the movement can be traced as far back as the early 1700s (Acton, 2011).

It is true that, with such practices engrained in our urban heritage, they have the advantage of being familiar and recognisable to potential members. Community orchards and pocket parks, on the other hand, do not have as long a history, at least in the urban environment and are therefore not as well established in the modern urban psyche. For this reason, such sites are not as recognisable as the more established practices of community and allotment gardening – a situation which may favour the latter in terms of community participation. Other, more practical factors may also play a significant role. In the case of community orchards, the group contained two of the three largest sites in the case study and the type mean was well above that of the sample for site area. As such, and in the case of all three orchards, sites were located necessarily where large amounts of green space were available, namely in municipal parks, recreational land and nature reserves. As such, none of the sites

in the community orchard category were able to be classed as “visible from the street” in the analysis (Table 5.6). This “out-of-the-way-ness” of some sites may explain to some degree why they are underused, underdeveloped in terms of on-site amenities and benefit from a smaller volunteer base than other sites. Although none of the community orchard sites were visible from the street, in terms of accessibility they all benefited from daily public access. Whereas this might be seen to be a factor which would encourage public involvement it may be that such open access has the opposite effect. Security may be an issue in that people wishing to dedicate their time and energy prefer to do so in a “safe” environment where access is limited to project leaders and fellow volunteers and where resources, structures and crops are safely kept within a protected site. As a management characteristic, site access in particular was effective in delineating sites in terms of volunteer input (Section 5.3.5). In this regard a moderate degree of limitation to public access appeared to be optimal for community participation. Moreover, sites which were positioned on or near municipal parkland may be assumed to be strictly under council maintenance and therefore not of public concern. The variability in CBF scores for pocket parks may also be due to this element of accessibility. One of the sites for example (Dale St.) was situated on a busy city-centre car park (with minimal signage) which many may assume is maintained by the local authority and as such “not their business”. Ironically, it seemed that publicly accessible features of the landscape which are made available for public use and are public property, may be among those which people are less likely to feel comfortable getting involved with. The fact that community allotments scored consistently high in this part of the study also adds weight to this theory. Each of the community allotments studied was subject to limited access where the site was only open to participating members at certain times of the week. At these times sites were open for “work days” led under the supervision of experienced gardeners (Section 5.3.1). Each allotment was also designed with communal areas and facilities in mind to accommodate volunteers. It may be that such conditions, with structured volunteer days, facilities and supervision could be more appealing to prospective participants than sites with a less organised schedule, low-level supervision and/or perceived issues around site safety.

Another factor affecting community participation may stem from the activities which take place at each site. As already mentioned in the discussion of regulating service provision, community orchards, for example, are generally managed with much less intensity than

gardens and allotments. Orchards, forest gardens and other permaculture approaches to gardening and agriculture attempt to mimic natural systems and advocate a minimal amount of environmental engineering. That being the case it is possible that, at these sites, there may simply be less “to do” due to the design of the garden or orchard requiring less maintenance. Allotments, on the other hand tend to be much less naturalistic, more intensive in terms of cultivation and demand a “hands-on” approach to food production. Similarly community gardens, which tended to combine areas designated for food production and other horticultural activities with recreational and communal spaces, would require a large amount of maintenance for the upkeep of the various elements of the site. Moreover, community allotments and, to an extent, community gardens delivered consistent, considerable yields which may be high on the list of reasons why members of the community wished to get involved.

It was clear that community gardens and allotments, with a regular supervised schedule provided conditions conducive to community involvement. Furthermore these sites were, in a sense, more “user-friendly” than sites from the other two types studied in the provision of basic facilities such as built structures for shelter, toilets and, in some cases, light, heating and food making facilities (Figures 5.6; 5.8; 5.10 and Figures 5.12; 5.14; 5.16). Such features could provide a more welcoming environment and help these sites to successfully deliver events and workshops, engendering engagement and raising their profile in their respective localities.

Of the pocket parks studied, although all were involved in fruit and vegetable production to some extent, the CBF score varied greatly. Interestingly, the site on Dale Street was, of the three, most intensively cultivated for food, so much so that no space whatsoever was designated for communal or recreational facilities. This may be one reason why this site achieved a considerably lower CBF score than the other two sites of this type. The real impact of such a site however is very difficult to gauge. Being situated in a very central location, open to the public and visible from hundreds of residences the actual impression created in the local area would require more in-depth investigation than was possible to carry out in this study.

Upon initial analysis, no strong relationship emerged between the extent of community participation and site size. All things being equal, one could reasonably expect larger sites to be able to accommodate more participants. There appeared to be no such relationship,

however, which suggests that site-specific factors such as the ones discussed above may bear more influence on community involvement than site size or, at least, play a modifying role in the relationship (this is explored further in Chapter 6). That said, it was evident that those very large sites (for example greater than 1000m<sup>2</sup>) showed considerable variation in the extent of volunteer input and the CBF score overall. Whereas pocket parks also displayed considerable variability in CBF scores, allotments scored consistently between 200 and 350. As such it could be said that community allotments provide the most reliable and substantial level of cultural ecosystem services of those sites surveyed. It can be deduced from these observations that site design considerations relating to geographic context and access were just as important, if not more so, than site size or management in terms of facilitating community input. It is necessary to note however, that the approach to the assessment of education and well-being as ecosystem services and, through that of volunteer hours, site management intensity, was based on a snapshot approach to site evaluations and employed the use of proxies. A fuller, in-depth investigation, perhaps employing more qualitative methods to an analysis of group structure and conducted in a time-based fashion, would offer greater insight into governance-related aspects and the sustainability of OSEIs.

#### **5.4.5 Variation observed in service provision**

The summary analysis carried out of the degrees of variation exhibited across services as presented in Table 5.14, demonstrates that of the four services selected, yield exhibited the highest degree of variation (cv = 0.78), followed by education and well-being (cv = 0.77) and biodiversity potential (cv = 0.59). Microclimate regulation exhibited a considerably lower coefficient of variation of 0.29, suggesting that the site conditions which determine GI score are those which are less easily modified than characteristics related to other services. This also implied that site GI function in general may have relatively little effect on overall performance in terms of the ability of sites to simultaneously produce other ecosystem services. (This is discussed further in Chapter 6).

The data in Table 5.14 demonstrate that of the sites included in the case study, community orchards exhibited the highest mean within-type level of variation in the extent of their provision of the selected ecosystem services (mean cv = 0.82). In terms of the four services



selected, food yield exhibited the greatest variation between sites and the highest coefficient of variation in the analysis was against CBF score by community orchards. Of all OSEI types, service provision by community allotments was the most consistent with the lowest mean figure for within-type coefficient of variation (Table 5.14, mean cv = 0.18). Furthermore, sites of this type exhibited low degrees of variation in terms of their overall contribution made to the selected services for the case study (Table 5.15, mean cv = 0.43), meaning that site output by community allotments was, of all types, the most evenly spread across the range of services. Although pocket parks were more productive overall by unit area, a comparatively high mean variance in level (mean cv = 0.42, Table 5.14) and evenness (mean cv = 0.64, Table 5.15) of provision between sites of this type suggest that they offer less consistent ecosystem service providing spaces. Yet lower consistency was demonstrated by community orchards (mean cv = 0.75, Table 5.15) which, with the exception of Philips Park Community Orchard, were the least multifunctional in terms of evenness of service provision.

#### **5.4.6 Relative social-ecological impact of case study sites**

Given the relative characteristics of sites according to their type, specific design elements and social-ecological contexts, it could be argued that the relative impact of each on their immediate environment varied accordingly.

In the case of community gardens, the three case study sites of this type all occurred in close proximity to reasonably extensive areas of both public and domestic green space compared to other types. In this sense these gardens fitted with the overall mean for this type as detailed in Chapter 4. As such, the impact of such sites may best be described in terms of social capital as opposed to ecological intensification. In fact, although all sites of this type studied involved the “regeneration” of previously DUN-classified land (Section 5.3.1), the creation of these community gardens, as an effective amenity space often involved a certain degree of sealing, the removal of trees, shrubs and other vegetation for the sake of improved access or to create space for vegetable beds or other desired features. In this way, although such sites appeared to ensure a form of “social” intensification through the increased utility of previously unused land, these positive impacts may simultaneously have

the polar effect of detracting from the level of ecological functioning and biological succession present in pre-existing conditions.

Similarly, community allotments included in the case-study were all situated at existing local authority-owned allotment sites (Section 5.3.1, Figures 5.13, 5.15 and 5.17). Their design and maintenance, therefore, was generally comparable to other allotment plots in the vicinity.

Thus, as in the case of community gardens, it could be argued that, given their spatial context, the greatest impact achieved by such sites was by virtue of the provision of a community resource, offering physical, educational and nutritional benefits to local users.

In the case of community orchards, sites were, of all the cases of OSEI studied, those which occurred in areas with the most abundant green space (Section 5.3.1, Figures 5.19, 5.21 and 5.23). As such it could be argued that such sites necessarily achieved a lesser impact with regards to the ecological intensification of their particular location. However, the case study community orchards all occurred on areas of existing parkland or recreational ground which, due to regular maintenance (characterised by intensive mowing regimes) exhibit generally low diversity of ecological succession and species richness (Weiner et al., 2011; Humbert et al., 2012). However, the creation of orchards as an essentially afforesting endeavour has obvious and proven ecological benefits (Gurr et al., 2003; Power, 2010) especially given the intensive regimes often adopted by local authorities in their management of municipal parks and recreational land. Moreover given that community orchards as a group exhibited comparably low CBF scores (Section 5.3.5), it can be said that the impact of this type of OSEI was primarily related to ecological outputs resulting from habitat restoration.

Perhaps the largest impact of OSEI, in purely ecological terms, was demonstrated by the clear increase in both the ecologically effective area and biodiversity potential of pocket of land by the creation of pocket parks. Being that such sites emerged at locations which were, previously, almost entirely ecologically unproductive (Section 5.3.1), the impact of this type of innovation was perhaps the greatest of all the approaches described, ecologically speaking. That pocket parks, as a form of OSEI, represented principally ecological gains in terms of their overall impact, is reinforced by the fact that socio-economic conditions, in contrast to ecological ones, were relatively favourable in site locations for this type, as illustrated in Section 4.2.6.

#### 5.4.7 Summarizing type characteristics

Although there was evidence of within-type variety in terms of the design, setting and genesis in the selected case study sites, there were nevertheless defining common characteristics of the four key provisioning approaches to OSEI observed in the case study. Community gardens in the study represented a highly flexible, utilitarian approach to land regeneration in highly residential areas in order to maximise the functionality of communal spaces as a community resource. Although all cases of this type designated a proportion of land to cultivating food, design varied considerably; from sites which placed greatest emphasis on leisure and amenity elements (Centenary Gardens, Figure 5.6), to those which were founded largely on educational principles (Fallowfield Secret Garden, Figure 5.8) to sites which took the form of vegetable gardens and promoted food production as the primary endeavour (Barlow Moor Road Community Garden, Figure 5.10).

Community allotments, in terms of site design, were homogenous in that they all shared the common goal of maximising site productivity in terms of crop cultivation which was reflected in the layout and management of sites. A standard approach to ensuring conditions most suited to food production involved, in all cases, the use of secure perimeter fencing, regular but limited access and a site design that ensured accessibility and basic amenities for service-users. The provision of an accessible but secure space ensured that cases of this type were the most consistent in terms of community involvement through volunteer input and events. Furthermore, community allotments were also the most consistent (in terms of productivity  $100\text{m}^{-2}$ ) for food yield and biodiversity potential.

Community orchards represented a low-intensity approach to food production and site management in general but exhibited nonetheless great variety in design and management. All sites were similar in terms of geographic context in that they were situated in or close to existing parkland or recreational green space. These sites were characterised by relatively lower scores in terms of volunteer input, especially at larger sites, and high ecological integrity, augmented by the afforesting of previously structurally uniform green space. Pocket parks, whilst exhibiting a variety of innovative approaches to ecological intensification, were particularly alike in terms of location, occurring in areas of high sealing and urbanisation. In response to this extreme context, sites were typified by highly innovative approaches to site restoration, in an attempt to reverse the ecological degradation of surface sealing through improvised greening and growing methods.

An exploration of site context, management and design as well as the variation in ecosystem service delivery has been dealt with in this chapter. Chapter 6 addresses the monetary value, trade-offs, synergies and site-specific factors involved in ecosystem service provision by OSEI.

## Chapter Six: Valuation, trade-offs and synergies of Ecosystem

### Service Provision

#### 6.0 Introduction

The presence, distribution and management of OSEI has been documented in Chapters 4 and 5 of this thesis. In order to gain an appreciation of the value added by OSEI to ecosystem services provided by green space in the study area, a monetary valuation was conducted which drew on those elements of services produced by OSEIs which provide tangible economic returns on semi-formal community driven green space management. Further to this, in order to understand the production of ecosystem services by OSEI as an urban social-ecological phenomenon, it was necessary to investigate the data on service production, presented in the case study of OSEIs in Chapter 5, for the presence of potential synergies and trade-offs. An evaluation was also undertaken of the underlying characteristics of OSEIs which contributed to site productivity.

An appraisal of the monetary value of those ecosystem services issuing from the presence of OSEI in the study area was conducted by combining information on the number of OSEIs in the landscape, as presented in Chapter 4, with data collected in the case study on ecosystem service production in Chapter 5 (see Figure 3.2). It was thereby possible, using proxy values from the available literature, to arrive at a summation of the expected value of services provided by OSEI in the study area. Following this monetary evaluation of service provision in the study area landscape, data on service provision by those individual OSEIs included in the case study were analysed in order to inform an understanding of service production by OSEI at the micro-scale, to complement the analysis of its distribution at the landscape-scale presented in Chapter 4. The production of individual services by OSEIs in the case study is presented initially as a gross product, independent of site area, and subsequently as a standardised level of productivity per unit area. The latter was then employed to investigate relationships between individual services as well as to evaluate the influence of a range of site attributes on the capacity to produce ecosystem services. Therefore the spatial and thematic patterns of service production were identified at the site level to complement those already captured at the landscape scale in Chapter 4. The salience of food as a catalyst

for the emergence of OSEI as illustrated in the mapping study in Chapter 4, was similarly asserted in the analysis of the productivity of case study sites, in which the extent of cultivation appeared to be pivotal to the production of a range of ecosystem services (Section 6.2.4).

This chapter therefore provides a synthesis of the social, ecological and physical attributes which were observed through the dual-scale approach to the characterisation of OSEI adopted in this thesis. This analysis then informs a discussion on the potential benefits and limitations of the presence of OSEI in the urban landscape towards ecosystem service provision, the emergence of resilient social-ecological networks, and the potential for incorporating such networks into urban planning strategies.

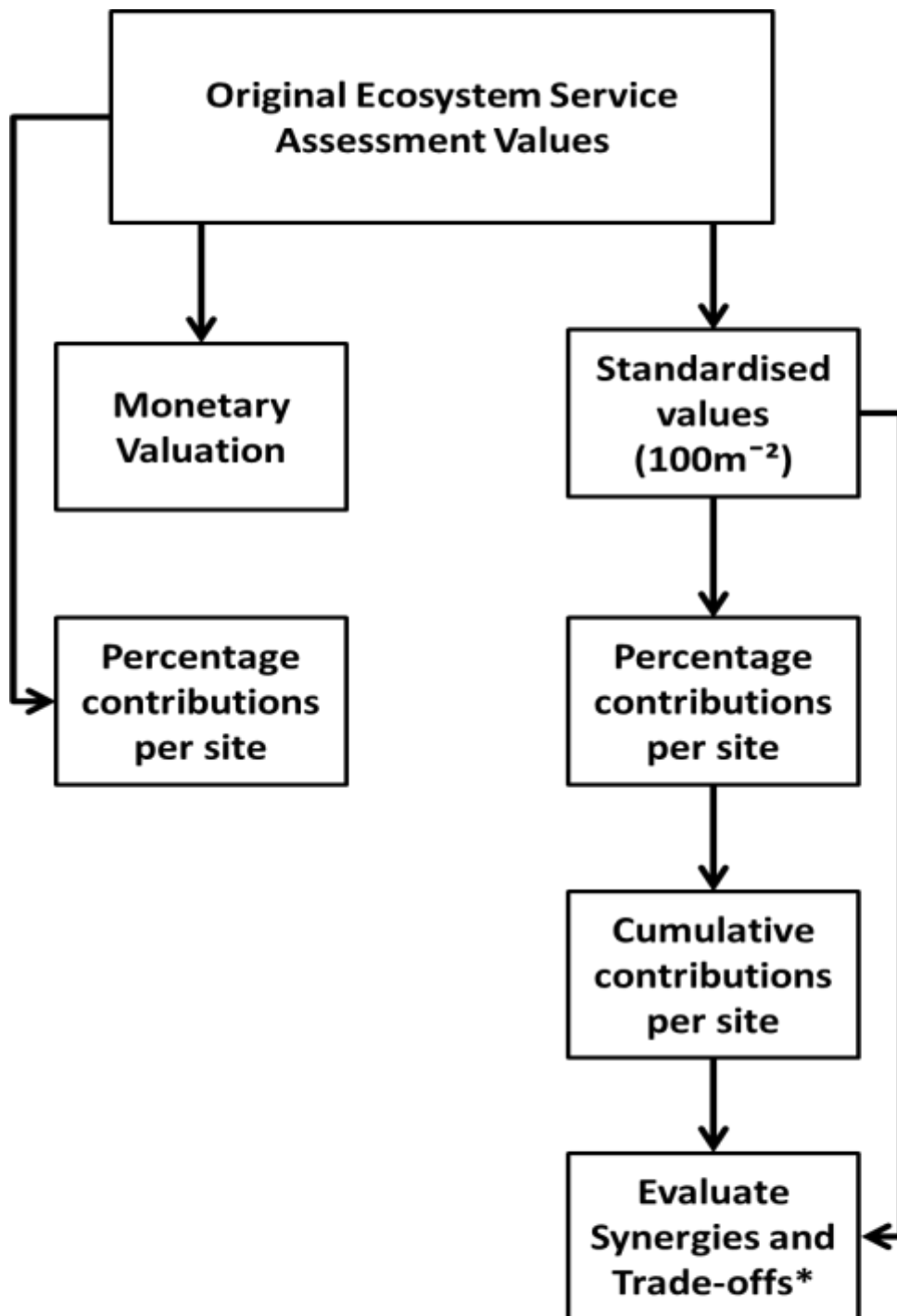
## **6.1 Methods**

The monetary value of the selected ecosystem services provided by OSEI in the study area was estimated by using a combination of proxy values obtained from the relevant literature. Proxy values were obtained from sources of ecological economics (namely, TEEB database, 2010), from comparable reports on the value of food production from UA, current (October 2014) food retail prices, value of therapeutic benefits from horticulture and government guidelines on the value of volunteer labour (sources detailed in Section 6.1.1). These proxies were then assigned to component elements of the selected services and goods which resulted from OSEI as revealed through the case study in Chapter 5.

The relative contribution of each site to the total ecosystem service provision for the case study was calculated. Given that the assessments for each ecosystem service resulted in values on dramatically different scales, each value was transformed into a percentage of the combine total for that service for the case study. This allowed for all four assessment scores to be rendered into a standard measure which enabled between-site comparisons of service provision. These contributory figures were then combined to give a cumulative score, indicating the level of total provision by each site.

The above process was then repeated using values from the ecosystem services assessments standardised by site area to give an impression of productivity per unit area (100m<sup>2</sup>). These data were then explored for evidence of synergies (i.e. correlations between/bundles of services), trade-offs and analyses were then undertaken to explore associations by looking at

particular site characteristics, namely, cultivation extent, genera richness, volunteer hours per month and vegetative extent/type. These four attributes were selected on the basis that they were all principle components of site design and each a key contributory factor in the tools used to measure service provision (food yield, biodiversity potential, education and well-being, and microclimate regulation respectively). The process is summarised in Figure 6.1.



\* Between individual services, overall provision and elements of site design.

Figure 6.1 Evaluating ecosystem service value, contributions and trade-offs: overview.



### 6.1.1 Monetary valuation of services from OSEI.

In order to estimate the total value of organised social-ecological innovation across the study area, monetary values were assigned to data pertaining to the selected services and goods which were provided in the case study in Chapter 5. The resulting estimated values were projected to reflect the full extent of provision by OSEI recorded in the mapping exercise as documented in the mapping exercise in Chapter 4.

Monetary values were chosen by obtaining proxies from the relevant literature and applying them to case study site characteristics. Values were calculated in three stages and summed as follows:

#### i) **Total economic value (TEEB evaluation) based on GI scores.**

The total economic value (TEV) for urban green space (climate, water regulation and recreation) in the form of US Dollars per hectare were obtained from the TEEB database (van der Ploeg and de Groot, 2010). These figures were converted into pounds sterling per 100m<sup>2</sup> and applied to the data for site GI score. Values for urban green space in the TEEB database were in 2004 dollars which were translated into GBP for the same year using data from the New York Federal Reserve Bank historical foreign exchange data (New York Federal Reserve, 2014). The result was then converted into a value for 2014 using the Bank of England Inflation Calculator (Bank of England, 2014). Accordingly, the TEEB urban green space TEV of US\$6111 ha<sup>-1</sup> yr<sup>-1</sup> was calculated at £3336 ha<sup>-1</sup> yr<sup>-1</sup> (= £33.36 100m<sup>-2</sup> yr<sup>-1</sup>) using 2004 currency exchange rates which was then translated to a 2014 value of £46.14 100m<sup>-2</sup> yr<sup>-1</sup>. This figure was subsequently applied to the total site area which was deemed to be ecologically effective according to the rationale of the GI toolkit used in the microclimate regulation assessment. For example, a 1000m<sup>2</sup> site with a GI score of 0.5 would give an ecologically effective area of 500m<sup>2</sup>. This was then divided into units of 100m<sup>2</sup> and multiplied by the £46.14 yr<sup>-1</sup> TEEB figures obtained for the total economic value of urban green space. The resulting value reflected the valuation potential of each site according to the total economic benefit of urban green space as outlined by van der Ploeg and de Groot (2010). However, the TEEB assessment did not reflect the small-scale, area-specific nature of OSEI and so values were also calculated for food production and for volunteer hours worked. This provided a more comprehensive evaluation of the contribution of OSEI to the local economy and social capital.

## ii) Valuation of site food yields

Figures for yields in pounds sterling per kilogram were calculated separately for vegetable crops, soft fruit and hard fruit. Values for vegetable crops were taken from the University of Pennsylvania's harvest report based on community gardens in the city of Philadelphia (Vitiello and Nairn, 2009), upon which values for case study site yields were also based. Valuation of vegetable crops in the Philadelphia Harvest Report (PHR) was established upon prices of comparable produce for sale at local farmers markets as opposed to supermarket goods (Vitiello and Nairn, 2009). This reflected the small-scale and largely organic nature of the cultivation process in community gardens. These particular characteristics of gardens in the Philadelphia study were shared by the case studies in this report and as such values from the Philadelphia research were adopted for valuation of vegetable crops in this thesis. These values were consistent across all scales of gardening assessed in the areas of Philadelphia as well as in Trenton and Camden (NJ) where the harvest report was replicated. Furthermore the mean value for crops was consistent despite the range of vegetable crops and varieties reported. The PHR therefore provided a suitable proxy for the value of food grown at OSEIs in this report where crop cultivation was similarly varied. Figures applied in the Philadelphia Harvest Report, for all gardens below half an acre ( $< 2000\text{m}^2$ ) were at a ratio of  $\$2.31 \text{ lb}^{-1}$ . Pounds were converted to kilograms and this 2008 US Dollar value was converted to GBP for the same year and re-calculated, allowing for inflation, to a corresponding 2014 value using the same method as for TEEB values above. The resulting amount gave an indication of vegetable crops as being worth  $\text{£}3.29 \text{ kg}^{-1}$ . Values for soft and hard fruit yields were sourced from current (October 2014) retail values for organic produce using apples as a proxy for hard fruit and raspberries as the soft fruit proxy. Prices were obtained from 8 local retailers (4 from local wholefood outlets and 4 from popular supermarket chains). Values were acquired from price-comparison websites where available (Mysupermarket Ltd., 2014), independent retailer websites (Carey Organic, 2014; Limited Resources, 2014; Northern Harvest, [no date]), and from in-store visits (Unicorn Grocery). This was done in order to reflect the availability of produce in the local area and to obtain a realistic appreciation of market value. The proxy figure for use in the valuation analysis was then taken as the calculated mean of these values. The mean retail price for apples was  $\text{£}3.85/\text{kg}$  and, for raspberries,  $\text{£}18.29/\text{kg}$  (Table 6.1). The total figure for site yield was then calculated using the above proxy values and used as an estimate of yearly summer harvest valuation.

**Table 6.1 Local retail prices for fruit produce.**

<b>Retail Outlet</b>	<b>Apples (organic, in £/kg)</b>	<b>Raspberries (organic, in £/kg)</b>
Carey Organic	3.50	16.00
Northern Harvest	3.50	16.00
Unicorn Grocery Limited	3.00	16.00
Resources	3.50	n/a
Tesco	3.80	20.00
Morrisons	4.50	20.00
Sainsbury's	4.50	20.00
ASDA	4.50	20.00
<b>Mean</b>	<b>3.85</b>	<b>18.29</b>

**iii) Valuation of volunteer input**

In order to appreciate the value of volunteer input as a tangible contribution to sense of place and maintenance of community resources, a value was obtained in the form of an hourly working rate based on figures from the Office for National Statistics and the Manchester Community Development Foundation (CDF). In their published guidance for community groups seeking funding for local regeneration projects, as part of a nationwide government-led initiative, the CDF places a value of £11.09 on every volunteer hour figured into government-matched bids (Manchester Community Central, [no date]). This was published as a guide for community groups as to the value of volunteer hours invested into projects which may then be matched by government funding. This figure, according to the Manchester CDF, publication, is taken from the Office for National Statistics' Annual Survey of Hours and Earnings, as the median gross hourly earnings rate. This figure was ratified against the most recent 2013 data from the Office for National Statistics which offered a median figure of £13.13 per hour and a mean of £15.87 for full-time employees. The figures for part-time employees were £8.29 (median) and £11.18 (mean). Given that the level of volunteer input at the case study sites reflected most accurately part-time working hours, these figures were considered in the analysis. Furthermore, the median was taken as being the more conservative estimate as the mean figure occurred between the 70<sup>th</sup> and 75<sup>th</sup> percentile for national earnings suggesting that this value was distorted by very high earning occupations. The median was therefore more indicative of a typical UK wage and this figure was subsequently applied to total monthly volunteer hours and used to give an annual total value.

#### **iv) Valuation of therapeutic benefits.**

Previous studies, as detailed in Section 2.4 of this thesis, have reported the benefits to mental well-being issuing from outdoor activities as a form of eco-therapy. The efficacy of such effects has been equated to that of professional counselling (D'Augelli and Hershberger, 1993) and the value thereof has likewise been established at rate of £40 per hour as the equivalent average cost of a profession counselling session (Munoz and Nimegeer, 2012). This figure was applied to the number of monthly volunteer hours recorded at OSEIs and projected to give a yearly total value.

Biodiversity was not entered separately into the monetary valuation analysis. The principal reason for this was that the standard method for valuing biodiversity as a service in its own right has been largely derived, in the field of ecological economics, from its contingent value, primarily through willingness to pay scenarios. It was not possible to provide a comprehensive account of the total contribution of the biodiversity potential of OSEIs to the study area as a cumulative figure using proxy values from such valuation methods. However, the figures provided by the TEEB database for "recreation" which were entered into the analysis using figures for site GI score effectively addressed that element of biodiversity for which it is often considered to be directly beneficial to humans and most readily translatable into monetary terms (see, for example, Pearce and Moran, 1994; Niemelä, 1999; DEFRA, 2007; Booth et al., 2011; Standish et al., 2012). Biodiversity and recreation are often seen as closely related and, in some evaluations, synonymous as ecosystem services and are frequently co-produced by service-providing land-use types such as urban parks (CABE Space, 2008; Müller et al., 2010; Breuste et al., 2013). As such the recreation element derived from the TEEB database, and reflected in site GI score, was considered as providing an inclusive measure of biodiversity valuation.

The total value of service provision by the twelve case study sites is presented in Table 5.2, with a breakdown of contributions across the four services. The three valuation estimates detailed above were then summed to give a combined economic value for all twelve case study sites. In order to arrive at an estimate of the total economic value of OSEI across the entire study area, the mean value was derived for the case study sites as economic output per 100m<sup>2</sup> unit area. This figure was subsequently used to give an estimate of the total value for OSEI recorded in the mapping study. This was calculated by taking the mean site area

from the case study and multiplying the corresponding valuation for this area by the number of OSEIs mapped in Chapter 4 according to the following equation:

$$OSEI\ value = \left( \frac{Mean\ site\ area\ (m^2)}{100m^2} \times mean\ value\ per\ 100m^2 \right) \times provisioning\ OSEIs$$

(n = 91)

### **6.1.2 Provision of ecosystem services, synergies and trade-offs**

Data collected from the ecosystem service assessments were computed for both total (gross) values per case study (as employed in the valuation method in Section 6.1.1) and as a standardised measure of site productivity by unit area (Chapter 5). The latter was used in an analysis of synergies and trade-offs in service provision. Using the standardized values obtained from the ecosystem service assessments of case study sites, the contribution made by each site to the case study total for each service was calculated as a percentage. Subsequently, site percentage contribution towards each of the selected services (n =4) for the case study were summed to give a measure of cumulative service provision. For each site, the resulting cumulative percentage, as an overall score, served to reflect the relative level of productivity of each site in terms of service provision by unit area. The transformation of the assessment scores into figures for units of 100m<sup>2</sup> resulted in a standardised dataset which could then be explored with greater confidence to identify correlations between services and underlying site characteristics. The subsequent calculation of the cumulative site contribution based on these standard scores, as a grand score reflecting site productivity, provided an effectively continuous variable for use in statistical analysis of site attributes and overall performance.

### **6.1.3 Evaluating synergies and trade-offs**

In order to arrive at a working method to evaluate the relationship between services and identify synergies between specific services and overall site performance, the standardised assessment scores on ecosystem service provision were treated as follows.

To understand the between-service relationships observed in service provision, the data were investigated, using IBM SPSS.20 for between-service correlations so as to identify potential synergies and trade-offs therein. The rationale was that positively correlated services might be considered as potential ecosystem service “bundles” (i.e. “win-win”

scenarios), with negatively correlating services suggesting potential trade-offs (“win-lose” scenarios) in the occurrence of urban ecosystem services provided by OSEI and urban amenity green space in general. Equally, service scores which exhibit no level of significant correlation, reasonably imply a certain independence, with the generation of such services not necessarily affecting the capacity for the production of other services and vice-versa. Further to this exploration of the relationships between services, analysis of principle site characteristics was conducted as an attempt to evaluate the underlying determinant factors, in terms of site design, structure and management, which contribute to the extent and spread of the ecosystem services thereby derived. Equally, the analysis was designed to focus on those elements which lead to particular emphasis on certain services so as to evaluate the possibility of targeting those services, or an optimal arrangement of services.

## 6.2 Results

### 6.2.1 Estimating the value of organised social-ecological innovation in Manchester, Salford and Trafford

Data on monetary values of site production for the selected ecosystem services was calculated as described in Section 6.1.3 and is summarised in Table 6.2.

**Table 6.2 Summary of monetary valuation of site service provision.**

Site	Site Area (m <sup>2</sup> )	Ecologically Effective Area (m <sup>2</sup> )	Total £ year <sup>-1</sup> *	Yield £ summer <sup>-1</sup>	Volunteer Hours-£ year <sup>-1</sup> +	Therapeutic Value £ year <sup>-1</sup>	Gross total £ year <sup>-1</sup>	£ 100 m <sup>-2</sup> year <sup>-1</sup>
Centenery	936	665	307	871	2653	12800	16630	1777
FSG	1530	1316	607	1825	19100	92160	113692	7431
BMRCG	560	554	256	2288	13264	64000	79808	14251
PLOT	950	703	324	9077	14590	70400	94392	9936
MSCA	780	616	284	6959	19896	96000	123139	15787
CCA	630	422	195	4160	13264	64000	81619	12955
SLCO	1044	1190	549	2472	1326	6400	10747	1029
BFFG	1734	1994	920	8723	5306	25600	40549	2338
PPCO	380	456	210	3840	10081	48640	62771	16519
Triangle	215	133	62	1072	9948	48000	59081	27480
Dale St	221	104	48	1729	2918	14080	18775	8495
HCGC	217	130	60	656	13264	64000	77980	35935
							<b>Mean</b>	<b>12828</b>

\* Based on TEEB urban green space Total Economic Value

+Projected for UK growing season Mar-Oct

#### Type Key:

community gardens

community allotments

community orchards

pocket parks

#### Site Key:

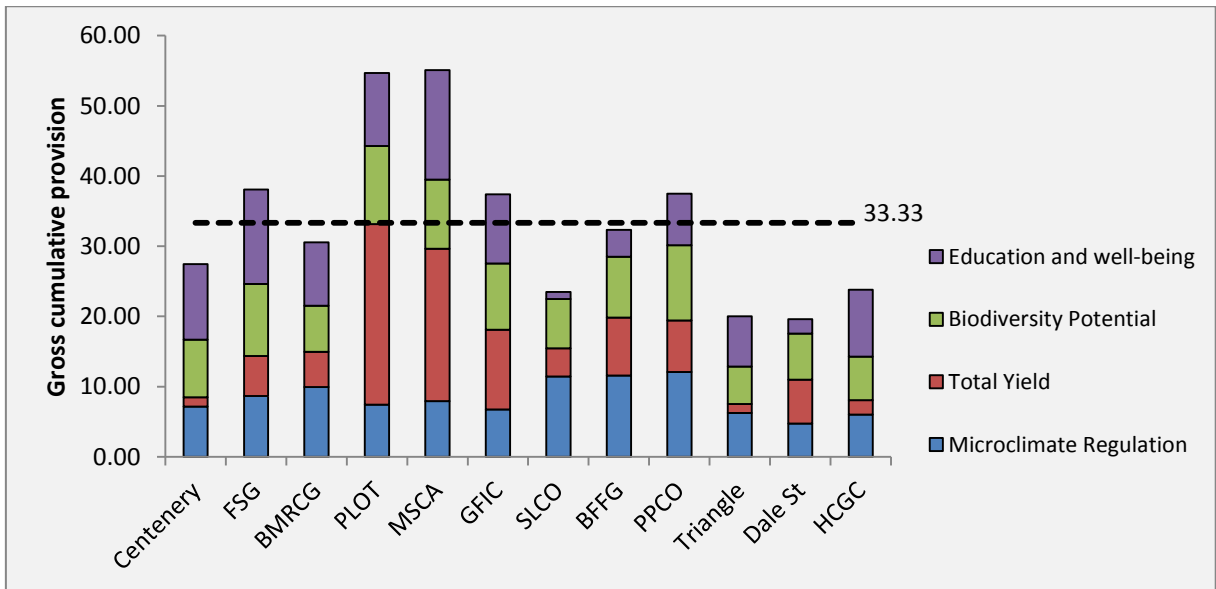
FSG = Fallowfield Secret Garden, BMRCG = Barlow Moor Road Community Garden, PLOT = Planting and Learning Old Trafford, MSCA = Moss Side Community Allotment, GFIC = Grow For It Chorlton, SLCO = Stenner Lane Community Orchard, BFFG = Birch Fields Forest Garden, PPCO = Philips Park Community Orchard, HCGC = Hulme Community Garden Centre.

The values in Table 6.2 demonstrate that the mean estimated value of the selected ecosystem services produced by the case studies was £12828 per 100m<sup>2</sup>. Taking the mean site area of 766m<sup>2</sup>, the total estimated economic value for all OSEIs across the study area (n=112) was calculated as:  $(7.66 \times £12828) \times 91$  (number of *provisioning* sites in the study area), giving a total estimated value of £8,941,801 yr<sup>-1</sup> for ecosystem services provided by social-ecological innovation in the study area. Given that estimated total area of provisioning OSEIs in the study area (68,940m<sup>2</sup>) equalled only 0.046% of the total figure for public green space (149,228,480m<sup>2</sup>), OSEI as recorded in this thesis equates to a considerable proportion (13%) of the total economic value estimated, according to TEEB guidelines, of urban public green space for the study area ( $14,923 \text{ hectares} \times £4614 \text{ ha}^{-1} \text{ yr}^{-1} = £68,854,722 \text{ yr}^{-1}$ ). In terms of value added by the presence of OSEI, the impact of innovative, community-led management of common green space (primarily due to gains in food yield and volunteer input from the presence of urban agriculture) resulted in a considerable increase from the baseline TEV figure (from the TEEB database) of £46 100m<sup>-2</sup> yr<sup>-1</sup> to an estimated £12828 100m<sup>-2</sup> yr<sup>-1</sup>.

### **6.2.2 Site contributions to service provision.**

In order to evaluate the overall contribution to ecosystem service provision by each site, figures for each service were initially calculated as a percentage of the study total and broken down by the four composite services to give a cumulative percentage (Figure 6.2).



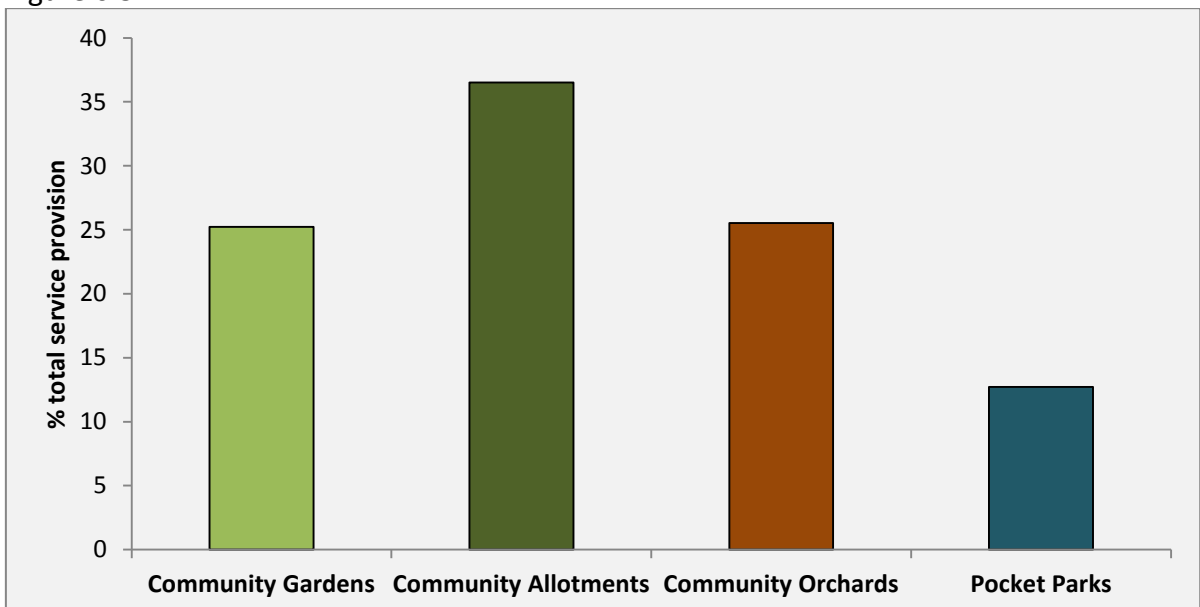


**Figure 6.2 Case study site cumulative provision score (gross) by ecosystem service.**  
**Mean = 33.3% ±14.02%**

**Site Key:**

**FSG = Fallowfield Secret Garden, BMRCG = Barlow Moor Road Community Garden, PLOT = Planting and Learning Old Trafford, MSCA = Moss Side Community Allotment, GFIC = Grow For It Chorlton, SLCO = Stenner Lane Community Orchard, BFFG = Birch Fields Forest Garden, PPCO = Philips Park Community Orchard, HCGC = Hulme Community Garden Centre.**

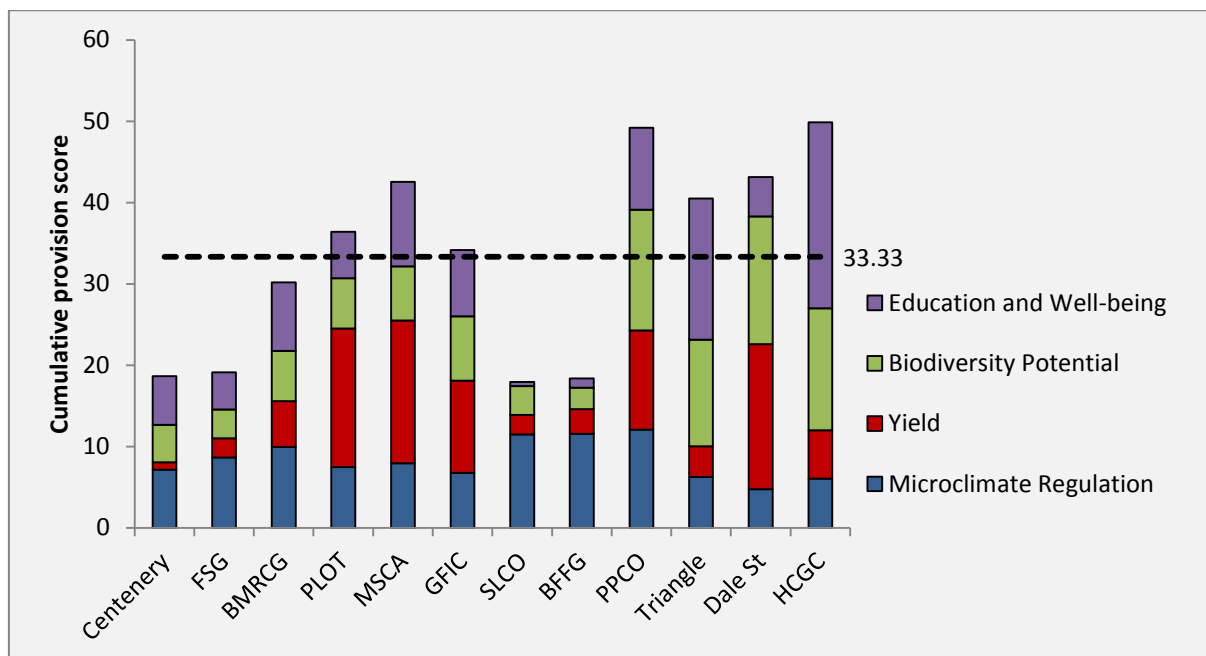
The relative contribution of each type of OSEI to the total for the case study is presented in Figure 6.3.



**Figure 6.3 OSEI type gross provision for case study services.**

### 6.2.3 Measures of site provision per unit area.

The gross figures for total site contribution were standardised as described in Section 6.1.2 and are presented in Figure 6.4.



**Figure 6.4 Contributions to case study cumulative provision score 100m<sup>-2</sup>. Mean = 33.3% ±11.4%**

**Site Key:**

**FSG = Fallowfield Secret Garden, BMRCG = Barlow Moor Road Community Garden, PLOT = Planting and Learning Old Trafford, MSCA = Moss Side Community Allotment, GFIC = Grow For It Chorlton, SLCO = Stenner Lane Community Orchard, BFFG = Birch Fields Forest Garden, PPCO = Philips Park Community Orchard, HCGC = Hulme Community Garden Centre.**

Of particular note, the second highest overall cumulative contribution (49.19%, Figure 6.4) to the total service provision 100m<sup>-2</sup> in the evaluation was allocated to Philips Park Community Orchard, which presents this site as performing strongly against the trend of its type. Mean figures for contributions by OSEI type, as a total percentage contribution, and broken down by individual services, are presented in Figures 6.5 and 6.6 respectively.

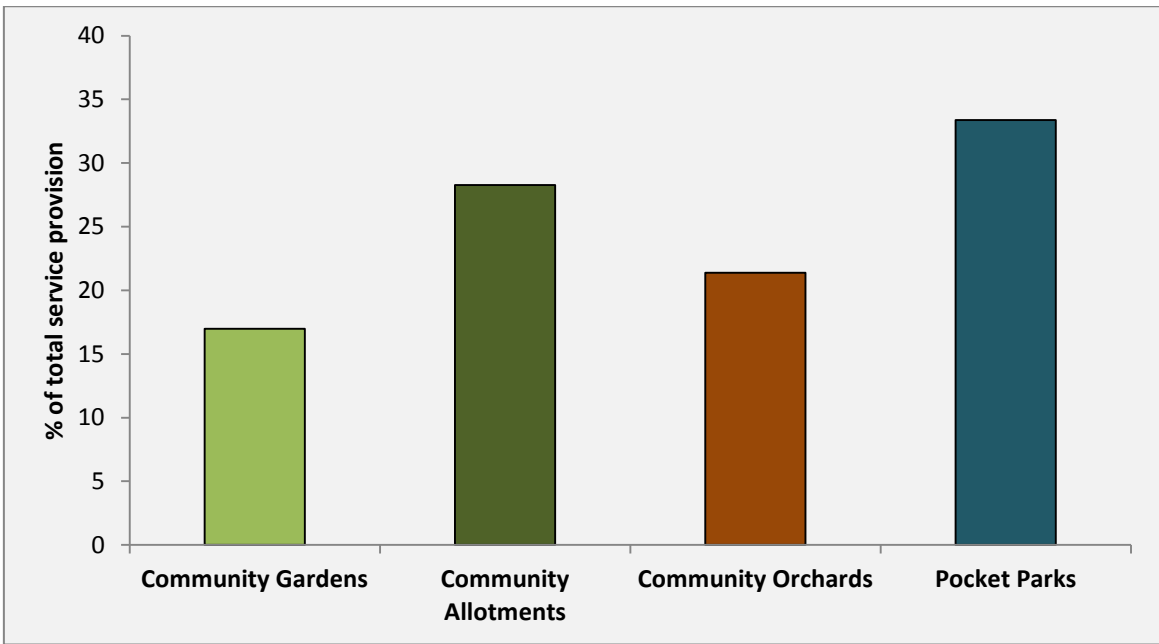


Figure 6.5 Type percentage provision  $100\text{m}^{-2}$  for case study services.

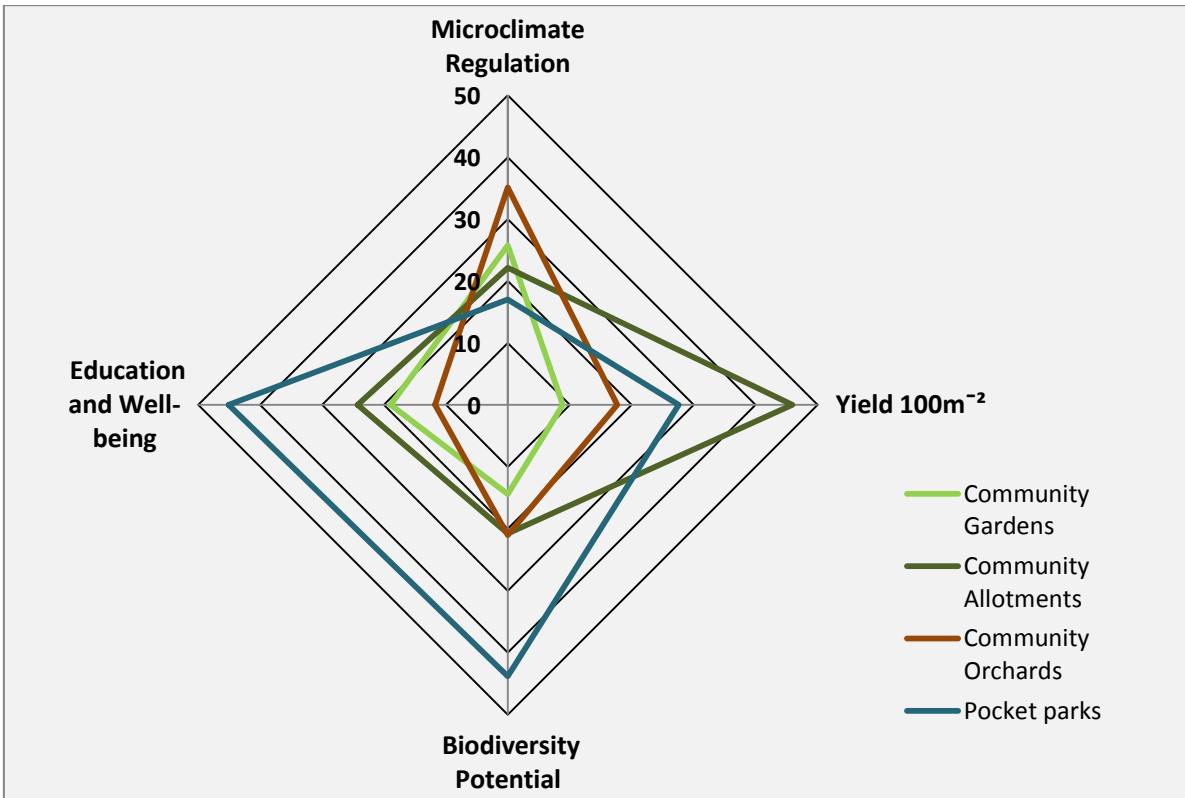


Figure 6.6 OSEI type mean percentage contribution  $100\text{m}^{-2}$  spread by service.

#### 6.2.4 Ecosystem service synergies and trade-offs

Site scores (standardised) for all four service assessments were analysed for positive and negative between-service associations and their relative influence on overall site performance was explored based on the level of correlation of each with the cumulative contribution score (Table 6.3).

**Table 6.3 Correlations between services and overall (cumulative) provision.**

		Microclimate Regulation	Food Yield	Biodiversity Potential	Education and Well-being
<b>Cumulative Provision Score</b>	Pearson Correlation	-0.384	0.651*	0.879**	0.719*
	Sig. (2-tailed)	0.218	0.022	0.000	0.008
	N	12	12	12	12
<b>Microclimate Regulation</b>	Pearson Correlation	-	-0.313	-0.444	-0.470
	Sig. (2-tailed)		0.322	0.148	0.124
	N		12	12	12
<b>Food Yield</b>	Pearson Correlation		-	0.405	-0.046
	Sig. (2-tailed)			0.191	0.888
	N			12	12
<b>Biodiversity Potential</b>	Pearson Correlation			-	0.663*
	Sig. (2-tailed)				0.019
	N				12

\* Correlation is significant at the 0.05 level (2-tailed).

\*\* Correlation is significant at the 0.01 level (2-tailed).

The correlation matrix (Table 6.3) presents biodiversity potential, of the four selected services, as having the highest correlation with cumulative provision score ( $r^2 = 0.77$ ;  $p < 0.001$ ). Education and well-being score also correlated positively with overall provision ( $r^2 = 0.52$ ;  $p = 0.008$ ). Site yield  $100\text{m}^{-2}$  correlated to a moderate degree ( $r^2 = 0.42$ ;  $p = 0.022$ ) with site cumulative provision score whereas microclimate regulation exhibited non-significant levels of association.

Of note was the weak, non-significant negative relationship between microclimate regulation and total contribution. This implied that the level of ecological integrity, although a key factor in providing microclimate regulating services may not be a limiting factor in the ability of urban green spaces, at least at small scales, to effectively produce other ecosystem services. Site biodiversity-area ratio, as a measure of biodiversity potential, with the highest correlation to total provision, presented as being potentially pivotal in understanding the factors which contribute to the ability of sites to produce a range of ecosystem services. The correlation matrix in Table 6.3 also displays information on the strength of between-service relationships. The tests presented only one significant correlation, that between biodiversity potential and education and well-being ( $r^2 = 0.44$ ;  $p = 0.019$ ). Other correlations between service scores were not significant and to that extent could be deemed as being more independently produced. Again, microclimate regulation, as determined by GI score, presented no significant correlations, reiterating its relative independence and the comparatively low level of variation found in this evaluation of microclimate regulation provision. The analysis implied that biodiversity in particular, or rather, elements contributing to that service, had a significant bearing on the productivity of sites across the range of services overall.

To evaluate these interactions further, an assessment was carried out of the underlying site attributes, recorded in the case study of ecosystem service provision (Chapter 5), which contributed to individual service provision and to site productivity overall. Data were collated on those principle site characteristics upon which assessment scores were primarily determined, namely: vegetation cover, percentage of site area cultivated, genera richness and volunteer hours per month. As vegetative cover, cultivation area and genera richness were characteristics standardised by site area; volunteer hours were likewise modified to give a spatial appreciation of site management intensity (all quantities were converted to values  $100\text{m}^{-2}$ ). Attributes which were measured as percentages all contained several scores below 20% and so were normalised via arc sine transformation prior to inclusion in the analysis. Scores for cumulative provision score proved to be normally distributed and were entered into the analysis unaltered.

Given that site area varied considerably within the case study and that the assessment of ecosystem services in this thesis was largely considered from a spatial orientation (i.e. in units of  $100\text{m}^2$ ), site area was also included among the site attributes in the analysis as a

characteristic which had bearing on overall service provision. Pearson's product-moment correlation tests were performed on the same basis as the analysis of between-services relationships (in SPSS.20). The correlation coefficients between site characteristics and site cumulative provision score are presented in Table 6.4.

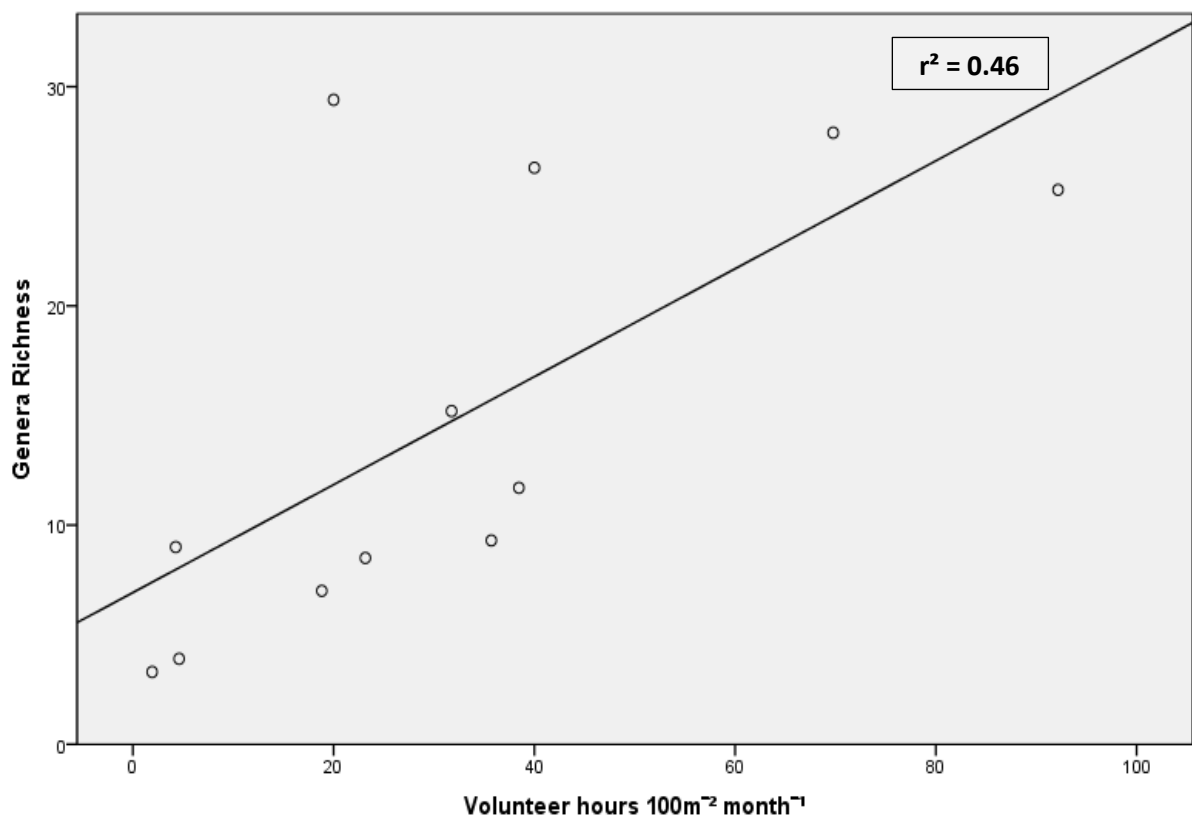
**Table 6.4 Site characteristic relationships.**

		<b>Vegetation Cover</b>	<b>Genera Richness</b>	<b>Volunteer Hours</b>	<b>Area Cultivated</b>	<b>Site Area</b>
<b>Cumulative Provision Score</b>	Pearson Correlation	-0.507	0.832**	0.760**	0.536	-0.817**
	Sig. (2-tailed)	0.092	0.001	0.004	0.073	0.001
	N	12	12	12	12	12
<b>Vegetation Cover</b>	Pearson Correlation	-	-0.638*	-0.465	0.169	0.580*
	Sig. (2-tailed)		0.025	0.128	0.600	0.048
	N		12	12	12	12
<b>Genera Richness</b>	Pearson Correlation		-	0.678*	0.305	-0.855**
	Sig. (2-tailed)			0.015	0.335	0.000
	N			12	12	12
<b>Volunteers Hours</b>	Pearson Correlation			-	-0.035	-0.688*
	Sig. (2-tailed)				0.915	0.013
	N				12	12
<b>Area Cultivated</b>	Pearson Correlation				-	-0.246
	Sig. (2-tailed)					0.441
	N					12

**\*\* Correlation is significant at the 0.01 level (2-tailed).**

**\* Correlation is significant at the 0.05 level (2-tailed).**

Of the values produced for correlations between site characteristics and relative to site cumulative score, vascular plant genera richness produced the highest positive correlation with cumulative provision score ( $r^2 = 0.69$ ;  $p = 0.001$ ). Volunteer hours per  $100\text{m}^2$  ( $r^2 = 0.58$ ;  $p = 0.004$ ) correlated positively with cumulative provision score to a moderate degree. Again, biodiversity, as indicated by the genera richness score, of the characteristics studied, were the most highly associated with overall site provision (cumulative score). In terms of between-characteristic relationships, genera richness correlated positively with volunteer hours ( $r^2 = 0.46$ ;  $p = 0.015$ ), and, counter-intuitively, negatively ( $r^2 = 0.41$ ;  $p = 0.025$ ) with percentage cover of vegetation connected to ground. The spatial dimension of site design in particular proved to be instrumental in the efficiency of ecosystem service provision by the case study sites. To gain an understanding of the influence of volunteer effort on biodiversity potential a linear regression was performed with volunteer input, measured in hours per month per  $100\text{m}^2$ , as the predictor variable. The relationship is visualised in Figure 6.7.

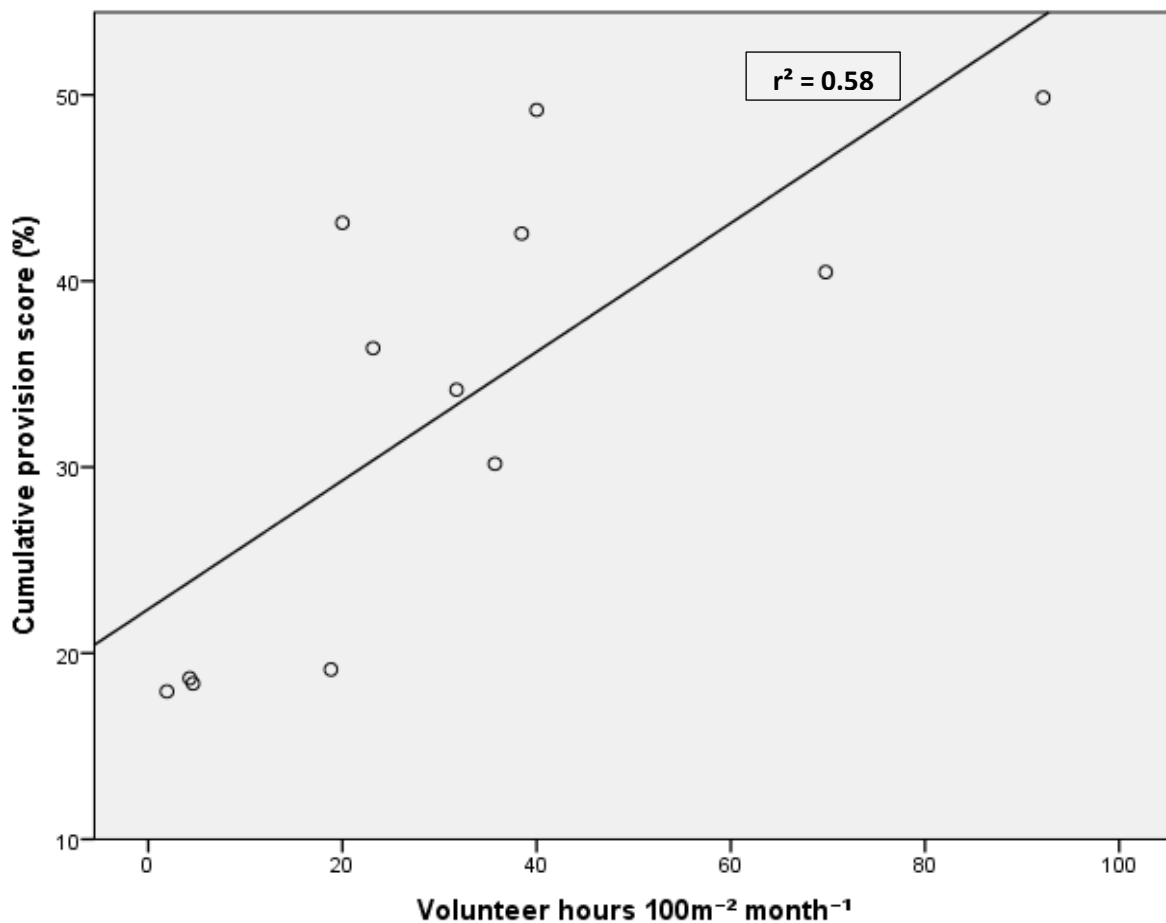


**Figure 6.7 Volunteer effort: effect on site genera richness ( $p = 0.015$ ).**

According to the regression analysis, site volunteer input accounted for 46% of the variation in site genera richness. With a beta coefficient of 0.68, the equation predicts that, for the case study scenario, every hour increase a day in volunteer effort per 100m<sup>2</sup> site area resulted, on average, in an increase of vascular plant richness of 7 genera for the same unit area on the predicted baseline value (i.e. no volunteer effort) of approximately 7 genera 100m<sup>-2</sup> (intercept = 6.9). The analysis therefore points to a positive relationship between community input and the generation of biodiversity potential at sites of social-ecological innovation. The result is, however, distorted by the two outliers in the analysis (top-left of Figure 6.7) without which the effect size is dramatically increased ( $r^2 = 0.85$ ). This latter version thereby presents a more reliable account of the relationship between community input and biological richness of sites.

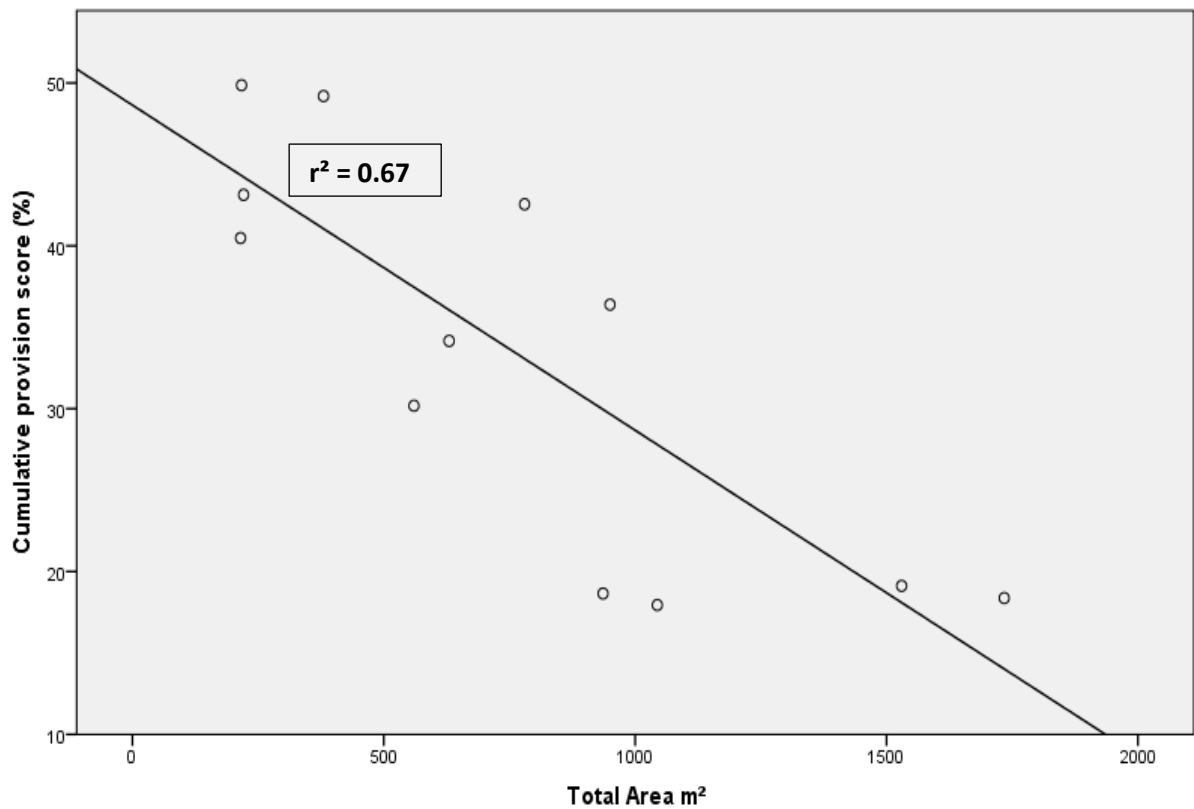
Overall, the genera richness score bore the greatest and most significant correlation with cumulative percentage contribution and as such presented as being the most indicative of the site characteristics contributing to overall service provision. Volunteer hours also demonstrated considerable synergy to cumulative provision score and, moreover, significant positive correlations were observed between these two characteristics. From these associations it was deduced, particularly given the context of sites as community managed spaces, that the three afore mentioned attributes of site output are highly influenced by human input. As such, they were to a large extent a consequence of community environmental engineering and a direct result of volunteer effort, as denoted in the strong correlation observed in Table 6.4 between volunteer hours and site cumulative score (and visualised in Figure 6.8).





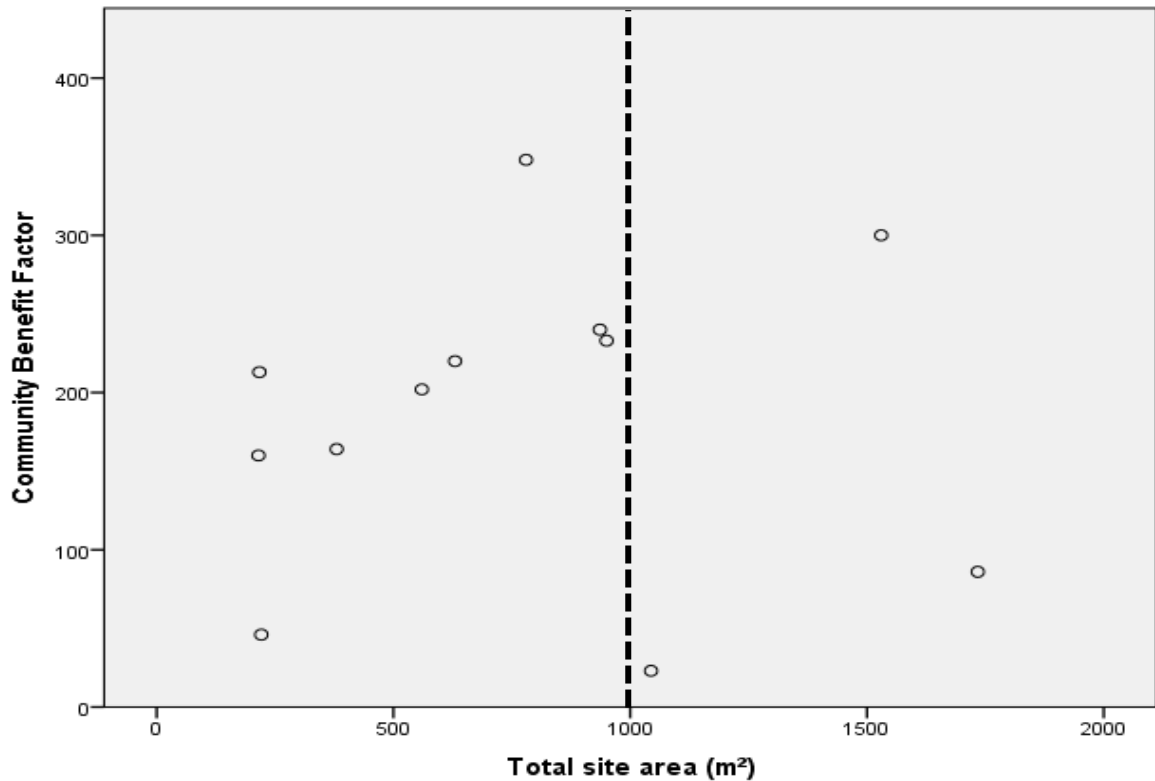
**Figure 6.8 Regression of site volunteer effort against cumulative service provision score;  $p = 0.004$ .**

Strong correlations were observed describing the relationship between site size and the service-related site attributes (with the exception of food cultivation extent). Specifically, site area correlated negatively with genera richness ( $r^2 = 0.52$ ;  $p = 0.001$ ) and volunteer effort ( $r^2 = 0.47$ ;  $p = 0.013$ ) as well as positively correlating to a moderate degree with percentage vegetation cover ( $r^2 = 0.34$ ;  $p = 0.48$ ). In terms of the relative effect of site area, the data implied that this element of design in the case studies bore a salient influence on the productivity of sites in producing ecosystem services overall ( $r^2 = 0.67$ ;  $p = 0.001$ , Figure 6.9).



**Figure 6.9 Effect of site size on ecosystem service productivity;  $p = 0.001$ .**

According to the analysis, community input had a significant bearing on site productivity (Figure 6.7) and, in turn, site size appeared to influence the former. This effect of site size was examined further by plotting this attribute against the community benefit factor (CBF) score employed in the site assessments for education and well-being in Chapter 5. This is depicted in Figure 6.10.



**Figure 6.10 Total site area and community benefit factor score.**

The scatter plot in Figure 6.10 presents increasing site area up to a value of 1000m<sup>2</sup>, as positively associated with CBF score (Spearman’s rho = 0.80; p = 0.01). However, beyond this value, the trend did not hold. This suggested that the ability of sites to engage community participation was considerably diminished above this threshold of site size, adding further weight to the idea that OSEI productivity is, to a large extent, a spatially conditioned phenomenon.

In order to control for between-characteristic associations and clarify synergistic effects on overall performance, analysis was conducted, by way of multiple regression, to delineate the relative effect of each on overall site service provision. Accordingly, percentage vegetation cover, genera richness, volunteer hours 100m<sup>-2</sup> month<sup>-1</sup> and percentage cultivation area were entered into a backwards conditional regression model (SPSS.20). The results of the regression model demonstrated that site cultivation extent, genera richness and volunteer effort were responsible for almost all of the variation observed in the overall relative performance by sites, with an r-squared value of 0.97 (p < 0.001). The output of the test revealed that, although genera richness demonstrated the highest correlation with overall

performance (Table 6.4), this variable was removed from the final model ( $p = 0.669$ ). Moreover, of the remaining variables in the final model, cultivation area exhibited the greatest partial and semi-partial correlations with cumulative provision score despite not having demonstrated significance in the Pearson's product-moment correlation analysis (Table 6.4). Vegetation cover exhibited a negative relationship with overall productivity. These relationships are summarised in Table 6.5.

**Table 6.5 Site attribute regression statistics. Dependent variable: cumulative provision score.**

Model	Unstandardized Coefficients		Standardized Coefficients			Correlations		
	B	Std. Error	Beta	T	Sig.	Zero-order	Partial	Semi-Partial
1 (Constant)	15.284	4.031		3.792	0.007			
Genera Richness	0.074	0.166	0.059	0.446	0.669	0.832	0.166	0.029
Volunteer hours 100m <sup>-2</sup>	0.276	0.044	0.607	6.273	0.000	0.760	0.921	0.414
Area Cultivated	0.560	0.082	0.587	6.838	0.000	0.536	0.933	0.452
Vegetation Cover	-0.159	0.056	-0.286	-2.867	0.024	-0.507	-0.735	-0.189
2 (Constant)	16.197	3.292		4.920	0.001			
Volunteer hours 100m <sup>-2</sup>	0.289	0.032	0.634	8.949	0.000	0.760	0.954	0.561
Area Cultivated	0.582	0.061	0.611	9.594	0.000	0.536	0.959	0.601
Vegetation Cover	-0.176	0.040	-0.315	-4.385	0.002	-0.507	-0.840	-0.275

Although cultivation area and volunteer effort exhibited comparable beta coefficients, with the latter exhibiting a slightly greater effect size, volunteer input appeared to have a relatively weaker relationship with overall site productivity than did food cultivation. This is indicated by the discrepancy in the respective semi-partial correlations produced in Table 6.5. which suggests that much of the positive contribution towards overall service provision derived from genera richness and volunteer activity issued from the degree of emphasis placed on food cultivation at given sites. The higher t-statistic (9.59) produced for

percentage area cultivated, of the three variables, lends further confidence to the predictive weight of food cultivation effort in the model. Data on area of cultivation was back-transformed for the purpose of interpretation. The regression equation subsequently explained that, in the case-study scenario presented in this thesis, an increase in area designated for food production by 10% of the site total led to a subsequent increase in site cumulative provision score of approximately 12%. Although this interpretation defies the allocation of an absolute value to the effect of site food cultivation extent, it gives an impression of the relative influence of food production in facilitating site delivery of ecosystem services overall.

### **6.3 Discussion of ecosystem service provision by organised social-ecological innovation**

#### **6.3.1 Extent of service provision by OSEI in urban areas**

The analyses described in the preceding sections of this chapter demonstrate that the presence of OSEI in the study area made a positive contribution to the ability of open spaces to produce urban-relevant ecosystem services. If data on the total economic value of green space provided by the TEEB database (as the sum value of climate regulation, water attenuation and recreation) are to be taken as an accepted baseline, then the result of organised social-ecological innovation as described herein is a considerable increase in value (see Section 6.2.1). It is important to note however, that “green space”, as defined in the ONS Generalised Land Use Database (GLUD) used in the mapping study (Chapter 4) and employed in the valuation estimates in Section 6.2.1, covered a variety of green space types. These included, for example, allotment gardens and urban farmland. As such, the monetary values of green space in the study area calculated based on Generalised Land Use Data, and using TEEB figures, are to be treated with caution given that the neither the GLUD nor the TEEB values employed in the assessment took full consideration of the multi-purpose nature of urban green space. Clearly, a re-appreciation of the multi-purpose, heterogeneous qualities of urban green space are required in order to arrive at adequate valuation and planning methodologies, as has already been acknowledged by the Commission for Architecture and the Built Environment (2010). Notwithstanding the shortcomings of the

available data, the analysis illustrated that significant gains are to be enjoyed from the social-ecological intensification which generally results from the informal management of green common spaces as an example of OSEI.

Further to the intensification in productivity brought about by social-ecological innovation in green spaces, there occurs, in many cases (pocket parks for example), an actual increase in the ecologically effective area of green *and* built surfaces. This is achieved either by intensive planting regimes leading to the vertical and horizontal ecological intensification, the conversion of hard-standing surfaces to vegetated ones or else by other improvised means such as green roofs and building facades or a variety of raised bed vegetation designs. As such the actual value added by OSEI is likely to be even greater than that projected in section 6.2.1, given that OSEI not only improves the ecological and amenity value of green space but, in effect, actually *increases* the physical extent of ecologically functioning spaces. The potential for increasing the social-ecological value of green space in urban areas is, for the services studied in this report, largely due to the goods and benefits which are the result of community-led urban agriculture: namely, food yield, social-ecological intensification of sites and the value of community volunteering involvement. Such benefits are not universally associated with urban green space in general, for example, in the assessments produced by (and partially employed in the monetary evaluation in Section 6.2.1) the TEEB research program (van der Ploeg and de Groot, 2010). However, such beneficial outcomes are, as derived from the practice of food cultivation, the cornerstone of organised social-ecological innovation as revealed in Section 4.2.1.

It must be stated also, that although the services selected for study were those which were most pertinent to the urban context and, as such, provided a useful measure of the potential of OSEI, they were not exhaustive in describing the potential for services which may otherwise issue from OSEIs. For example, food production provides a service in itself but has associated benefits such as the preservation of genetic diversity, heirloom crop varieties, and social-ecological memory (for example, across generations) as well as by-products in the form of useable organic materials (e.g. compost, mulch, organic fertilisers). Urban agriculture also has the potential to bring about gains by way of maintenance of soil nutrient levels, diversity of soil micro-organisms and the phytoremediation of low ecological quality, derelict or contaminated land (Khan, 2005). Further to this, the valuation of OSEI calculated in Table 6.1 was based on sites which were primarily land-based and as such disregarded

environmental resource centres in the analysis. However, the social and, indirectly, ecological capital derived from such primarily educational enterprises may be of significant value. Although the activities of such sites took place primarily on premises, the buildings which housed such projects often contained ecologically innovative and energy efficient features such as green facades and were in some cases annexed by small areas of garden used for either relaxation or training in horticulture or other ecological activities. Environmental resource centres also served to facilitate other greening projects either through skills sharing and training or networking events, or simply as social-ecological hubs for the spread of ideas. An accurate appraisal of the various use and non-use values of such spaces would require further research. Suffice to say that the projected value of social ecological innovation undertaken in Section 6.2.1, given the above caveats, is likely to be conservative in nature.

### **6.3.2 Trade-offs and synergies in ecosystem service provision**

The analysis of associations between individual services highlighted only one synergistic relationship: that between biodiversity potential with education and well-being. On the other hand, the same analysis offered no evidence of significant negative correlations which would identify trade-offs between services. The data therefore describe a scenario where services provided by organised social-ecological innovation are, in large part, done so independently of one another. Although it was not possible to establish a high degree of mutual productivity of individual services, the lack of potential conflict between services suggests that it may be possible for multiple services to be targeted by instances of OSEI, primarily by virtue of site design. Not only is such a situation possible but can be also desirable based on the fact that the second most productive site in the case study (Philips Park Community Orchard, Figure 6.4) and the most consistently productive type of OSEI, community allotments (Table 5.14), also achieved the most even spread of service provision (Table 5.15). The impact of small-scale site design on the productivity and multi-functionality of sites is therefore clearly revealed by the data, a consideration largely ignored in previous assessments of urban ecosystem services which have tended to adopt a more linear approach to evaluating service provision at the landscape scale (e.g. Goldman et al., 2007; Lavorel et al., 2011).

Although few instances of either synergies or trade-offs were discovered, the correlation matrix presented in Table 6.3 revealed that different services correlated to varying degrees with overall provision. Of particular note was the lack of a significant correlation between GI score, as a measure of microclimate regulation, with other services but also with overall provision. That the ecologically effective area of sites, defined by the GI assessment, did not have a significant bearing on the total capacity for service provision demonstrates the potential for innovative approaches to urban greening such as those seen in examples of OSEI, particularly pocket parks, to generate ecosystem service-providing micro-scapes in areas of poor ecological quality and/or high surface sealing.

### **6.3.3 Site characteristics and service provision**

The analysis of ecosystem service provision by sites in terms of gross product (Section 6.2.2) presented community allotments as making the greatest contribution to the total for the case study with pocket parks (being the smallest sites on average) contributing the least. However, assessing productivity from a spatial orientation, by unit area (Section 6.2.3) revealed that pocket parks were the most productive type of OSEI. This measure of productivity, assessed from a spatial dimension, was negatively associated with increasing site size (Figure 6.9), suggesting that smaller sites were more efficiently productive in terms of overall performance. Given that cultivation extent and volunteer effort were both highly influential towards total site product (Table 6.5), it can be logically inferred that smaller sites more readily achieve a high level of management intensity compared with much larger sites. Total volunteer input, for example, did not increase proportional to site size and, being that human and community resources are finite, larger sites suffered from a lack of management intensity due to such limitations. As a result, site size was in fact negatively correlated with volunteer input per unit area (as well as with site genera richness). Social-ecological innovation based at small scale sites may therefore be likely to provide, from a spatial viewpoint, a more efficient return in terms of service provision than those occurring on a larger scale. This inverse site-size productivity relationship mimics the already established, counter-intuitive, inverse farm-size productivity relationship (Alvarez, 2004; Section 2.9), whereby smaller OSEIs apparently exhibited greater productivity. Although a multi-scale approach has been adopted in research seeking more adaptive management of urban



ecosystems (Ernstson et al., 2010), little work has been done on the spatial aspect of service delivery itself, particularly from a social-ecological viewpoint. The data analysis in this and previous chapters offer insight into the landscape presence as well as the on-the-ground productivity of multifunctional spaces as spatially sensitive elements in social-ecological systems, a characteristic previously ignored in the literature.

Site area was, particularly, negatively correlated with genera richness (Table 6.4), whereas the latter appeared to increase proportional to community input (Figure 6.7), as indicated in the analysis of volunteer effort. The negative effect of increasing site size on productivity was mirrored by a similar influence exerted by percentage vegetation cover on genera richness (Table 6.4). This describes a situation which goes against the usual accepted model of species-area relationships (Rice and Kelting, 1955; McGuinness 1984) and runs contrary to general assertions in other urban studies as to the adverse effects of urbanisation (e.g. Helden and Leather, 2004; Thompson et al., 2004; (Godefroid and Koedam, 2007).

Accordingly, the analysis presented in Section 6.2.4 contradicts expectations around the effects of area and urbanisation levels on biodiversity. The implication, therefore, is that, with the concerted semi-formal management of green commons, such deleterious effects can be subverted through the creation of bio-diverse microhabitats. Clearly, there was a linear relationship between site biodiversity potential and site area with the latter also being influential on volunteer input (Table 6.4), which in turn correlated with genera richness (Figure 6.7). The latter result, although statistically significant was distorted and effectively reduced by two outliers in the analysis: Dale Street Car Park and Philips Parks Community Orchard. These two cases exhibited anomalously high biodiversity scores relative to volunteer input. This may be due to a variety of possible factors at play at these two sites. The data collection did not take into account experience or specific levels of horticultural knowledge which may have been unusually high in these cases. Similarly, repeated measures were not factored into the snapshot approach and accordingly the two outliers may have exhibited variation in levels of vascular plant diversity or management intensity which were seasonally distinct from the other cases in the study. It is also possible that some data obtained on volunteer hours from site members may have been provided with a degree of inaccuracy. However, in both the versions of the analysis, with or without the inclusion of these outlying cases, the positive effect of volunteer effort on biodiversity potential is clear and statistically significant. It is also important to note that the two anomalous cases were

highly productive in terms of biodiversity and, in that sense, do not detract from, but support an appraisal of community involvement as positively influencing biodiversity levels. This presented a social-ecological dynamic whereby, similar to expectations drawn from species-area curves in natural systems, larger sites could be expected to exhibit lesser species richness (Scheiner, 2003). However the high level of anthropogenic input found in OSEI appears to heighten this effect, the outcome being a linear species-area relationship moderated by (human) community input. The situation in such a social-ecological context is, however, necessarily more complex than in more naturalistic habitats, where ecological productivity and intensification of sites in, specifically, urban settings is largely a function of site management (Figs. 6.7, and 6.8), the latter also being a factor conditioned by spatial considerations (Table 6.4; Figure 6.9).

Furthermore, given the size of these pockets of land (Table 5.5), which are generally too small to be considered as prominent sites for redevelopment but which may constitute significant areas when considered at the landscape scale, their ecological intensification should be particularly beneficial.

The relatively insignificant associations between microclimate regulation and other services in the analysis presented in Table 6.3 demonstrated that the extent of site vegetation cover had little positive impact on total service provision, and in fact correlated negatively with biodiversity potential. This counter-intuitive relationship can be explained by the fact that sites with greater vegetative extent tended to be larger and, possibly as a result of low volunteer input or due to type-specific management practices (for example, intensive mowing regimes and suppressing of ecological succession) were less intensively cultivated and, accordingly, less diverse in terms of structure and plant genera.

There was a clear dynamic co-occurring between site area, volunteer input and biodiversity whereby larger sites were subject to greater and more frequent disturbance by mowing regimes, and as such, large areas of these sites exhibited low vascular plant richness and minimal structural diversity. In this sense the levels of biodiversity at OSEIs were subject to the same pressures as seen in studies on other urban land-use types (e.g. Niemelä, 1999; Dauber et al., 2003; Weiner, 2011). The difference being, however, that multi-functionality as a trait of OSEI management, when achieved to a significant degree through site design and an emphasis on crop cultivation, served not only to buffer against the homogenisation of habitat types, but to actively increase the level of biodiversity potential.

The bearing of management intensity on plant genera richness is echoed in the positive correlations noted between volunteer input and total provision (Fig. 6.8). Given that smaller sites more readily achieved a high level of cultivation intensity, site size played a significant role in productivity measured by unit area as described by the negative correlation observed between total site area and cumulative score in Table 6.4.

Volunteer input, genera richness and cumulative provision score all shared a strong degree of synergy in the analysis (Table 6.4) with food cultivation extent not correlating significantly. However, the further exploration of the determining factors in overall site provision, carried out by the multiple regression analysis summarised in Table 6.5 offered an alternative description of the situation. The regression analysis, controlling for confounding correlations between site characteristics, revealed that the intensity of site cultivation for food bore a stronger influence on overall site provision.

#### **6.3.4 Independence of service provision**

Although certain synergies and trade-offs were identified between site characteristics and ecosystem service provision, importantly, no statistically significant trade-offs were found to exist between individual services (Table 6.3). The proportion of site area as vegetation connected to the ground bore a negative correlation with genera richness but this relationship was not, however, reflected by a corresponding trade-off between biodiversity potential and microclimate regulation. The latter did exhibit weak negative correlations with other services in the assessment but none of them proved to be significant (Table 6.3). This would suggest that a range of ecosystem services can be achieved relatively independently of microclimate regulation.

In this sense, the results of this report run contrary, from the micro-scale perspective, to the unanimous notion in urban ecology that greater green infrastructure is always better (see, for example, Tzoulas et al., 2007). At the micro-scale, an innovative approach to urban greening as observed to varying degrees in the design of case studies in this report, proved to be effective in elevating small built-up sites to an acceptable (according to BREEAM standards) level of ecological functioning, challenging the emphasis on the need for “native” nature in the urban landscape as already questioned by the likes of Sagoff (2005) and Kowarik (2008 and 2011). Importantly, although GI score was largely a result of the proportion of site area comprising vegetation connected to the soil substrate, this was not

the only determining parameter in the GI toolkit employed in the assessment. Other surface cover types such as vertical and raised vegetation, various types of semi-permeable surfaces as well as shrub and tree layers played an important role in the ecological intensification and effectiveness of sites (see Section 5.3.1 and 5.3.2). It was therefore possible for sites with lower degrees of ecological integrity associated with impervious surfacing to achieve high potential for microclimate regulation by the presence of more improvised, diverse vegetative structures and planting regimes. Such potential was borne out by the fact that Philips Park Community Orchard, although not exhibiting the highest proportion of site area as vegetation connected to the ground, achieved the highest GI score for the case study (Table. 5.7). This would seem to infer that even in the greener areas of our cities such as existing allotment sites, parkland and nature reserves; there is considerable scope for simultaneous social *and* ecological intensification, with a range of associated benefits. Following this management example it should be possible to increase the social-ecological functioning and productivity of such areas, a scenario which quite happily contradicts the accepted idea that “wilder is better” and that making space for human activities leads to increased urban habitat destruction (as in Sukopp, 2004; Markovchick-Nicholls et al., 2008; Shochat et al., 2010).

This analysis also calls into question that which is to be regarded as functional green space. Efforts to evaluate ecosystem service provision have often been focussed at the landscape scale in an attempt to correlate large habitat types with certain services or bundles of services (Goldman et al., 2005; Raudsepp-Hearne et al., 2010; Lavorel et al., 2011; van Berkel and Verburg, 2014) as well as monitor land-use change over time (Nelson et al., 2009). The research presented in this thesis suggests that such an approach may not be satisfactorily replicable in the urban environment, given the modified, heterogeneous and ephemeral characteristics of urban green space as well as its multi-purpose utility. Increased knowledge of the functionality of various urban green space types would be necessary before the services derived from such spaces can be quantified at a landscape scale. The approach taken in this thesis provides an example of such a social-ecologically sensitive approach.

### **6.3.5 The centrality of food for social-ecological innovation in the urban landscape**

The prominence of food production in the evidence gathered on existing examples of social-ecological innovation was documented in Chapter 4 of this thesis and highlighted urban agriculture as a powerful catalyst for the emergence of OSEI and, as such, a foundational activity with beneficial associated social-ecological outcomes. Not only are the obvious direct-use benefits of urban agriculture (in terms of provisioning services) incredibly relevant to the emergence of adaptive urban food systems (Viljoen, 2005), alleviation of food poverty and the wider promotion of resilient social-ecological systems (Barthel et al., 2013), but, as highlighted by the analysis in the previous sections of this chapter, food production brings with it synergistic properties leading to the effective production of other pertinent ecosystem services for the urban landscape.

Not only did an emphasis on agricultural activities appear to correlate with levels of overall productivity of OSEI in the examples examined in this thesis, but those sites where food production received the greatest emphasis in terms of management and where, consequently, provisioning services were highest (community allotments) were also the most consistent in terms of overall provision. Such sites, whose design was centred around the cultivation of food as the overriding imperative, exhibited a greater evenness in provision across the range of services assessed in the case study and displayed a higher degree of homogeneity, with the lowest mean between-site variance of all four types. This presented sites where the highest proportion of land was dedicated to agriculture as the most reliably productive in terms of ecosystem services overall. The site which demonstrated the highest degree of productivity per unit area (Philips Park Community Orchard) and achieving also the greatest evenness in service provision was, in terms of site design and management, the case study most extensively cultivated for food (see Table 5.8). Almost 70% of this site was dedicated to cultivation which was achieved through the combination of horizontal and vertical intensification by a stratified approach comprising root crops, flowering plants as well as soft and hard fruit varieties. As such, Philips Park Community Orchard achieved a level of horizontal and vertical structural diversity which resulted in very high overall productivity.

Similarly, food cultivation was highly pronounced in the design of community allotments which comprised the only type for which all sites scored above the mean for cumulative

provision score in terms of both gross as well as the area-standardised measure of productivity.

As asserted in the literature review in Chapter 2 and the discussion following the mapping study in Chapter 4, the subject of food encompasses a range of topical social-ecological concerns. In particular issues touching on food poverty and sovereignty, ecological and environmental degradation and the tensions which exist around land sharing and sparing are all embraced to some degree by the topic of food. As such urban agriculture constitutes a social-ecological “flagship” concern which facilitates the ability of environmental, community and academic groups to explore innovative solutions to interconnected social and environmental problems. As such, it is logical that OSEI takes food cultivation as a foundational practice and testament to the catalytic nature of urban agriculture as a service providing activity that those sites which place particular emphasis on crop cultivation provide greater, more uniform and consistent output in terms of the ecosystem services studied in this research thesis.

The ascendancy, and productivity, of urban agriculture has been previously documented, largely in the context of developing countries (Maxwell, 1995; Mbiba, 1995; Altieri et al., 1999; Bakker et al., 2000; Bryld, 2003) and, more recently, cities in developed nations (Wunder, 2013; Kulak et al., 2013; McClintock et al., 2013; Hardman, 2014). The context and drivers of its occurrence have not been comprehensively explored however, nor the details of its productivity. The research presented in this thesis on the phenomenon of organised social-ecological innovation, which exhibited a characteristic involvement in food cultivation, offers insights that can facilitate a broader understanding of the spatial attributes of community-led urban agriculture. At the macro-scale, the distribution of such forms of urban agriculture is neither random nor uniform, but conditioned by current and historical social-ecological influences and urbanisation patterns (Chapter 4). At the micro-scale, site productivity was apparently scale-dependent and sensitive to management intensity, cultivation extent and site design (Tables 6.4 and 6.5, Figure 6.8 and 6.9).

Given the acknowledged gains stemming from forms of UA in terms of biodiversity restoration (Barthel et al., 2010), improved physical and mental health of participants (Relf, 1992; Heliker et al., 2001; Sempik et al., 2005) and climate change mitigation (Kulak et al., 2013), a working knowledge of those principles which influence both the distribution and productivity of OSEI, as determined in this research, could have important implications in the

planning of resilient, productive urban landscapes. Furthermore, the current study, by identifying the synergistic influence of food provisioning on the production of other services at the urban local scale, also demonstrates that the intensity and design of site cultivation affects the overall benefit issuing from these multifunctional sites in terms of a range ecosystem services. As such, the importance of the specifics of site design, management and materials on the productivity of innovative land-use types has been herein addressed, recognising the diversification and adaptability of bottom-up green space management, a consideration hereto largely neglected in the literature.

Given the elucidation of such patterns in the distribution of OSEI presented herein and those factors which contribute to the production of ecosystem services at the site level, there may be scope for further research exploring the life-cycle of OSEIs as an adaptive, ephemeral phenomenon. Observing management (and governance) of examples of OSEI over time would help to answer questions regarding site-specific adaptability of OSEIs and monitoring changes in patterns of distributions according to fluctuations in surrounding social-ecological conditions would offer more insight into the changeability of those thresholds explored in Section 4.3.4. Qualitative investigations in governance of OSEIs would also build on knowledge of the subject by informing an understanding of how social-ecological actors and groups adapt to changing social, environmental and economic opportunities and stressors.

## Chapter Seven: Summary

### 7.1 Assessing the value of social-ecological innovation in the urban landscape

The research documented in this thesis has provided insight into community-led, organised social-ecological innovation as a phenomenon which is significantly shaped by spatial characteristics in terms of its appearance, expression and productivity. In this respect, OSEI is simultaneously a response to, and an outcome of, its immediate environment. As such it represents an adaptive, niche-driven form of semi-formal resource governance.

The evidence for OSEI in the study area landscape presented in this thesis (Chapter 4) and its capacity for harnessing valuable ecosystem services (Chapters 5 and 6) indicate that considerable social and ecological gains are to be made from the presence of such innovation in the urban fabric. The analysis presented in Chapters 4 and 6 revealed that organised social-ecological innovation occupied a geographically small but, in terms of ecosystem service provision, significant, presence in the study area landscape. The projected valuation of OSEI in Section 6.2.1 demonstrated that the phenomenon brought with it considerable potential for added-value to ecosystem services, thereby addressing research objective 5.

As was discussed in the mapping exercise in Chapter 4 of this thesis, the distribution of examples of OSEI were influenced by both physical features of the environment and socio-economic conditions, likewise was the occurrence of different *types* of OSEI determined by such factors. In this way, types of OSEI occurred according to their particular social-ecological niches. As a result, OSEI presents an example of a diverse adaptive response to specific social-ecological conditions. The cornerstone of OSEI appeared to be a characteristic emphasis on communal green space restoration taking food production as a medium for social-ecological activism. Accordingly the conclusions of Chapter 4 effectively addressed objectives one and two of this research. Although the evidence collected in Chapter 4 identified a typology of five principal approaches to OSEI, it was clear from site surveys presented in the case study (Section 5.3.1) that each expression of social-ecological innovation is unique and a result of its particular adaptation to circumstances.

As underlined in the previous chapter (Section 6.2.1), the area covered by OSEI in the study area equated to less than 0.5% of the total green space cover, but made a significant



contribution to the total value of the latter. This demonstrated that, at the landscape scale, OSEI is already having considerable economic impact where it occurs in urban areas. Furthermore, when one considers the context in which such innovation occurs (primarily areas of low ecological quality (Section 4.2.3) and higher than average social deprivation (Section 4.2.4), the actual impact on site localities, relative to pre-existing social-ecological conditions, is considerable. Such impact can therefore only be underestimated in this stage of the research. Again, at wider scales, the potential for more integrated social and ecological networks may be considerable (Figure 4.23). In particular, gains should be possible in terms of the biodiversity potential offered by small improvised pockets of innovative green space types in areas with very high surface sealing and minimal ecological interest. Such examples of ecological improvement could provide vital sinks in highly urbanised sections of cityscapes, increasing habitat heterogeneity and connectivity with otherwise isolated patches of green space.

## **7.2 Biodiversity and social-ecological intensification by OSEI**

In terms of biodiversity, the possibility of reconciling the historically destructive nature of the urban human-environment relationship has been given support by the findings in this report on the positive correlation between levels of community-led ecological participation and increasing biodiversity potential in pockets of urban green space (Section 6.2.4). As such, OSEI with an emphasis on urban agriculture, as presented in this study, offers one means by which the commonly accepted trend of decreasing environmental quality and species diversity associated with urbanisation (Marzluff, 2008; Niemelä et al., 2002; McDonnell and Hahs, 2008) can be redressed. In this sense, the findings of this research echo those in recent literature which have championed the value of urban domestic gardens as comprising important ecological networks which may make significant contributions to urban biodiversity conservation (Smith et al., 2006; Davies et al., 2009; Goddard et al., 2010; Goddard et al., 2013). The potential contribution of OSEI to such ecological networks carries with it, the creation and strengthening of social-ecological networks which, if acknowledged by agencies at higher levels of governance, could contribute to the resilience of urban resource management. In terms of the ecological intensification achieved by OSEI, spatial context was pivotal (Section 5.4.6). Not only does OSEI appear to bring about genera rich

and structurally diverse pockets in the landscape (Tables 5.10 and 5.11), but its distribution was such that it generally served the most urbanised locations. That being so, the impact of OSEI is, ecologically speaking, often increased given its physical context (Section 5.4.6). By illustrating that OSEI was a spatially defined phenomenon finding niches in, for example, areas of extremely high surface sealing (Table 4.11), the current study provides a compelling case for the potential gains of integrating OSEI into highly urbanised areas for biodiversity conservation. Not only did OSEI add dramatically to ecological interest when occurring in areas of very high sealing, but also in more natural settings where OSEIs were found such as parks and recreational land, ecological gains were possible through increasing the species richness of these intensively managed, often highly homogenous, green space types (Section 5.4.6). The presence of this effect was underlined by the relatively higher biodiversity scores achieved by the case study sites (Table 5.10) compared to the more naturalistic areas in the study area upon which the original assessment method was piloted by Tzoulas and James (2010) (see Section 5.3.4). The social-ecological intensification permitted through OSEI was largely a result of community participation in the management of communal green space for food production (Table 6.5). Such intensification is contextualised in the analysis of OSEI distribution and typology in the landscape study in Chapter 4 and quantified, by examples, in the case study in Chapter 5. The correlational analysis in Chapter 6 provided detail of the linear, synergistic relationships that existed between urban agriculture, community participation and the wider provision of ecosystem services (Table 6.5; Figure 6.8). These conclusions thereby address research objectives three and six of this thesis, highlighting the synergistic social-ecological feedbacks inherent in OSEI through its distribution and productivity.

### **7.3 Site design considerations in multi-functional urban micro-scapes**

The exploration of site design and ecosystem services in Chapters 5 and 6 demonstrated that a uniformity in the level of provision across services was achievable and also desirable. The case study which exhibited the second highest cumulative provision score, Philips Park Community Orchard (PPCO), also presented the lowest variation in level of provision across the four services in the assessment (Table 5.15). Importantly, Philips Park Community Orchard made the second highest overall contribution to the total service provision per unit

area by the case study sites, although in terms of the individual services, this site ranked highest only in the case of microclimate regulation. PPCO therefore bucked the trend of the case study overall for which microclimate regulation as a service, and vegetative extent as the main determinant characteristic thereof, appeared to have no significant positive effect on overall levels of provision (Tables 6.3 and 6.4). This site, the second most highly productive in the study per unit area, demonstrated the potential for providing a range of services simultaneously to a considerable extent (Table 5.15). PPCO was unique in demonstrating both effective ecological functioning and biodiversity potential as well as delivering direct use goods such as food and recreational opportunities to a high level. This simultaneity in provision was primarily by virtue of site design, materials and management, as described in Section 5.3.1.3 and Figure 5.22, which allowed for the multi-functional nature of the site. The details of such a design could provide a valuable template for the enhancement of ecosystem services issuing from urban public spaces and the successful creation of multi-functional green space in the urban landscape.

In particular, PPCO achieved a high GI score helped by the fact that it was situated in municipal parkland, and was able to retain both microclimate regulating function (Table 5.7) and high biodiversity potential (Table 5.11) by virtue of intensive planting regimes, high vascular plant species richness and a diverse structure comprising a dense canopy with high levels of stratification. Being that much of the tree canopy consisted of hard fruit species and that this was complimented by the rotation of a variety of top fruit and vegetable beds, the site also maintained a keen emphasis on crop cultivation. These factors, along with the employing of highly porous natural materials for paths and limited use of built structures provided a highly naturalistic but accessible site design which clearly contributed to its capacity to simultaneously deliver numerous ecosystem services at consistently high levels. Site size appeared to be influential in the capacity of OSEI to effectively deliver the social and ecological intensification of spaces characterised by an inverse site-size productivity relationship (Figure 6.9). This resulted in the emergence of highly productive multifunctional micro-scapes, the most improvised examples appearing in the form of pocket parks. Not only did such small-scale sites achieve a relatively greater degree of ecological intensification resulting in, for example, high levels of biodiversity potential (Table 5.11) but, given the low ecological quality of the spaces in which such sites generally occurred (Figures 4.15, 5.25, 5.27 and 5.29), their impact was particularly great. Furthermore these innovative micro-

scapes, due to their size and modular design, ought to be easily repeatable and included into urban planning considerations.

The potential for high levels of social-ecological intensification exemplified in the case study sites presented in this thesis, as multifunctional micro-scapes, could provide a key element in the planning of joined-up multifunctional green infrastructure. Such multi-functionality should feature as a principle component of resilient urban landscapes but is an ingredient of urban design which has been largely overlooked in government planning policy statements to date (CIWEM, 2010). The approach adopted in this thesis, focussing on an appreciation of urban micro-scapes based on their local social-ecological contexts and their distribution in the wider landscape, addresses the need for an understanding of the spatially-oriented ingredients of multifunctional urban spaces for the sake of integrated resilient green infrastructure planning (CIWEM, 2010). Moreover, an evaluation of the design characteristics and productivity of OSEI as described herein (in Chapters 5 and 6 specifically) addresses more fully the social aspects of semi-formal green space management. This social (community) element to OSEI, which provides the context, impetus, knowledge and energy inputs for local ecosystem management, whilst simultaneously comprising the beneficiaries of the outputs of OSEI in terms of ecosystem services, has likewise been hitherto largely ignored by UK government planning policy statements. By demonstrating that social-ecological innovation generates such positive feedbacks in terms of effective green space management and the production of a range of ecosystem services, this research has highlighted the need to re-consider and value the potential contribution of semi-formal ecological governance as part of an urban planning framework. The assessment of the multifunctional nature of OSEIs resulting from design and management considerations as outlined in Chapter 5 thereby addresses Research Objective Four of the thesis, detailing the actual anatomy of OSEI at the site level as a reification of social-ecological engagement.

#### **7.4 The efficacy of food as a foundation for social-ecological intensification**

Perhaps the clearest detectable theme in the establishment of OSEI from the study and the key to its emergence and productivity is the prominence of urban agriculture as an effective medium for a variety of types of social-ecological innovation (Section 4.2.1). Not only did urban agriculture as a social-ecological concern appear to drive the emergence of OSEI but

subsequently, it was shown to have a significant synergising effect in the production of a range of ecosystem services (Table 6.5). Evidence for the importance of urban agriculture on the occurrence of OSEI was found to exist throughout the study area and its influence on site productivity was documented across all types included in the case study analysis. The cultivation of food provides an effective template for the horizontal and vertical intensification of the social-ecological activities and functions which can be derived from green spaces and, as demonstrated in Section 6.3.3, this aim is particularly reproducible at the micro-scale. Examples of OSEI in the case study revealed the possibility, through intensive site management centred on food cultivation, of achieving high productivity in terms of direct-use goods (food yield) as well as other direct-use benefits relating to physical and educational activities (Section 5.3). Additionally, desirable quality in terms of effective ecological functioning as well as consistently high scores for biodiversity potential were simultaneously realised by a food-centred approach to social-ecological innovation. This was evidence by the consistency shown in service provision by the most food-oriented sites: community allotments (see Tables 5.14 and 5.15) and by the synergistic attributes exhibited by food cultivation (Table 6.5). In this way, OSEI, focussing on urban agriculture, provided a multi-functional platform for a variety of physical, educational, and social activities. Not only did food cultivation provide an effective on-the-ground catalyst for OSEI but, given the influence of the food industry on environmental processes at local, regional and global scales (Section 2.8), it has the potential for creating a “flagship” effect on raising environmental and ecological awareness. This effect was clearly realised at case study sites, the majority of which adopted, wherever possible, organic, closed-loop resource management strategies and offered educational activities which promoted such sustainable methods (Section 5.3.1). One of the greatest strengths of OSEI in the management of local urban spaces was related to the positive social-ecological feedbacks inherent in its productivity whereby community involvement (in food cultivation) simultaneously constituted a key input (in terms of site management) as well as an output (in terms of education and well-being). Further to this, volunteer input correlated positively with overall site productivity (Figure 6.8). In this way the dynamics of OSEI presented a self-productive closed-loop of goods and services and contributed to the wider support of urban ecosystem services as part of a landscape-scale phenomenon where the symbiotic production of social and ecological capital are facilitated.

## **7.5 The role of social-ecological innovation for resilience building in urban areas**

As detailed in Chapter 4, the emergence and distribution of OSEI in the study area landscape represented a diverse social-ecological response to low quality urban environmental conditions (Sections 4.2.3 and 4.2.4). The combination of particular levels of social and ecological deprivation provided the impetus for local community-led natural resource management (Section 4.2.7). As such OSEI was a direct result of the capacity of local actors to self-organise in the face of worsening social-ecological conditions. According to the analysis, an area-specific degree of low ecological quality, characterised particularly by poor provision of domestic gardens, was the most significant driver of the occurrence and expression of social-ecological innovation (Sections 4.2.3 and 4.2.6). This would imply that urban residents not only value the green space that is available to them, but that they are actively concerned about its productivity and management. The notion that high levels of ecological disturbance associated with increasing urbanisation were the key driver of OSEI was supported by the high centrality of OSEIs with 69% occurring within 5km of the city centre (Figure 4.3). That said, poor socio-economic conditions also accompanied the occurrence of OSEI (Section 4.2.4) and, given that 90% of OSEIs recorded were involved in food production (Section 4.2.1), it can be inferred that concerns around food poverty (see Section 4.4.4) are implicit in the emergence of OSEI. That significantly higher levels of health deprivation co-occurred with OSEI (Table 4.3) adds weight to the notion that the latter is a response to the deleterious effect of social-ecological deprivation on community well-being. As such OSEI constitutes an important element for the adaptive capacity of the social-ecological system associated with the study area. It is important not only its adaptability to circumstances, as denoted by the diversity of OSEI design and types of OSEI (Section 5.3.1), but in that it was able to produce valuable ecosystem services in otherwise ecologically poor quality areas (Section 4.2.3).

Furthermore, that OSEI took food production as a primary activity and that this practice was positively associated with overall ecosystem service production (Table 6.5), increasing the value of urban green space (Section 6.2.1), cements the phenomenon as one that should contribute effectively to adaptive capacity and resilience of urban areas. OSEI was embedded in the adaptive cycle of the study area social-ecological system and accordingly was subject to the thresholds and traps which define such cycles. Specifically, OSEI, although driven by higher than average levels of social-ecological deprivation, was precluded once

such deprivation crossed a certain threshold. The presence of a certain degree and type of social capital was therefore pivotal in the self-organisation of local communities. Particular importance appeared to hang on the presence of social capital in the form of young educated residents, students and the significant presence of minority groups (Section 4.2.4). Education and community diversity were thereby seemingly vital in the adaptive capacity and self-organisation of neighbourhoods.

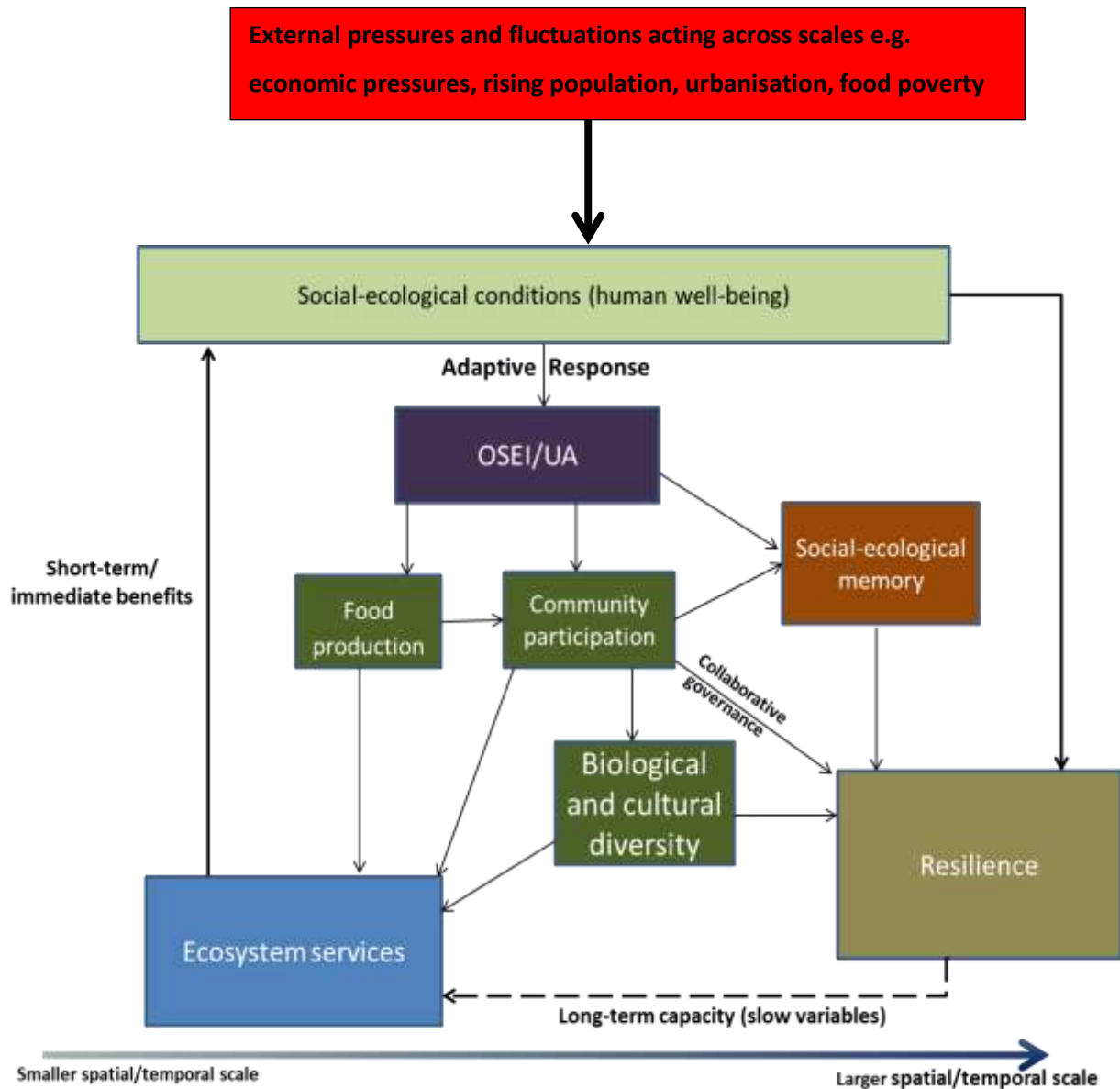
Conversely, the absence of these crucial elements of social capital, as defined by adaptive cycle theory, could explain the presence of “traps” in the cycle whereby innovation and re-organisation is prevented. Insufficient social mobility hinders the promotion and execution of new ideas, leading to “poverty traps”. In terms of the current study, such traps were identified in the landscape as social-ecological “blackspots” (Section 4.2.7).

The study identified the presence of hubs of education, training and innovation, such as environmental resource centres and other prominent examples of land-based OSEI, which may act as the kind of brokers in urban social-ecological networks, bridging the gap between top-down and bottom-up approaches to the management of green resources, which recently promoted governance frameworks (such as Ernstson et al., 2010) have called for. The prominence of such hubs and the surrounding social-ecological networks which they serve (see Section 4.4.5) may provide a route to the partial decentralization and diversification of urban green space management which in turn would lead to more adaptive semi-formal institutions in the future (Bodin et al., 2006; Andersson et al., 2007; Ernstson et al., 2010; Boyd and Folke, 2011). The distribution of discrete types and levels of OSEI in the landscape constitutes an extensive and supportive social-ecological network (Figure 4.23). Therefore OSEI, as a landscape phenomenon, exhibits those key attributes necessary for system resilience, namely: capacity for self(re)-organisation, response diversity, connectedness and cross-scale actors (Folke et al., 2005). Specifically, self-organisation is permitted by social capital in the form of high levels of education (Figure 4.12), response diversity is underpinned by cultural (Figure 4.5) and biological diversity (Table 5.11) with connectedness and cross-scale bridges being provided by supporting forms of OSEI and epistemic shadow networks (Figure 4.23). Such elements in the urban environment could provide the kind of adaptive capacity necessary to navigate, and thrive in, all stages of the adaptive cycle.

In this way, OSEI has the potential to fulfil many of the requirements which contribute to an effective resilience approach to ecosystem services management as detailed in Section 2.6 of this thesis. The semi-formal and improvised management of open spaces by self-organising community members and stakeholders contributes to a diverse bank of management approaches, builds on local learning and participation and has the potential to increase connectivity and the availability of social-ecological knowledge and memory. Given that OSEI effectively added to the productivity, in terms of ecosystem services, of under-used and/or poor quality green space and brought about the social and ecological intensification of pockets of land, it also creates positive social-ecological feedbacks and, through the cultivation of food in particular, acts as a medium for education and, accordingly, a retainer of social-ecological memory. The possibility of moving towards polycentric forms of governance could include or mimic an approach to local civic land management as exemplified by OSEI in the current study.

The multifunctional, adaptive nature of OSEI and its cyclical, synergistic relationship with urban ecosystem services has been evidenced throughout this thesis. In doing so, the two overarching research aims, which sought to evaluate the role of organised social-ecological innovation in the adaptive governance of urban ecosystem services, have been effectively informed. An overview of the implications for sustainable urban social-ecological systems informed by the relationship which exists between OSEI, ecosystem services, and social-ecological resilience is presented in Figure 7.1.





**Figure 7. 1 Overview of OSEI-related feedbacks in sustainable urban social-ecological systems.**

As summarised in Figure 7.1, the emergence of OSEI in the social-ecological landscape represents a mediating element which bridges, and augments, the three key management aims relating to resilience, ecosystem service provision and social-ecological conditions, occurring primarily as an adaptive response to the latter. As an innovative response to external and internal stressors characterised by socio-economic, environmental and nutritional deprivation (see Section 4.4.4) and mediated by specific social-ecological circumstances (Sections 4.3.4 and Sections 4.4.1 to 4.4.3), OSEI contribute to system resilience as a form of adaptive green space management which accordingly builds on and transmits social-ecological knowledge. The validity of such a response is confirmed by the resulting positive correlations, primarily through community participation and urban

agricultural practices, with vital ecosystem services, namely food production, biodiversity potential, and education and well-being. OSEI therefore provides a positive catalytic link in the cycle of ecosystem management and builds on synergistic feedbacks between social and ecological capital in the urban environment.

## **7.6 Recommendations and scope for future research: harnessing the potential of social-ecological innovation towards more self-productive, resilient towns and cities**

Key benefits are evidently already being produced by semi-formal approaches to the management of communal green spaces in urban areas. Accordingly, the promotion and support of OSEI, as an example of bottom-up environmental entrepreneurship, by local and national government bodies and NGOs (from a top-down perspective), would likely harness further the potential of social-ecological innovation which is finding a place in urban areas. By providing channels for local ecosystem management, the decentralisation of governance in urban green resources could be partly facilitated through an integration of civic ecological participation as evidenced by OSEI in the study area of this research.

Given that food production appeared to be associated with the most consistent provision of ecosystem services by OSEI, it constitutes one element of OSEI design which can be confidently encouraged in the urban landscape, regardless of pre-existing social and ecological conditions (bar complications due to site contamination), as a reliable conduit for the creation and harnessing of important ecosystem services. The analysis of variation in service provision in Chapter 5 revealed that sites which placed the greatest emphasis on food cultivation as a management focus, primarily community allotments, were also the most consistent in the level of provision that they were able to achieve. Cities, as home to the majority of the global population, are at the nexus of the supply and demand dynamics which drive the international food industry, itself being one of the leading drivers of climate change on the planet (as documented in Section 2.8) As such, the re-integration of agriculture as a viable and visible element in the urban fabric could have important socio-environmental benefits in terms of education (particularly on climate related issues), consumer behaviour change and, given that urban areas are centres of innovation and decision making, as well as policy-based and technological advances.

OSEI also provides a convincing example of the benefits which can be enjoyed when stakeholders are at the forefront of the decision making process regarding the management of their own ecosystems. This insight may have important implications for the future creation of resilient social-ecological systems, particularly in the urban context where environmental degradation has a daily impact on quality of life (Commission for Architecture and the Built Environment, 2010). Small-scale, community-led management of green commons may constitute a platform for the further understanding of urban social-ecological systems and provide opportunities for research-led and citizen-led collaboration towards increasing the adaptive capacity of our cities and towns. In effect, the urban landscape could be seen as a rich context for studying the dynamics of social-ecological systems and their associated resilience traits as well as a valuable source of innovative ideas, networks and practices which will inform the adaptive management of social and ecological capital as the current century unfolds. A further exploration into some of the conclusions derived from the largely quantitative approach adopted in this study, employing qualitative methods, may help to further elucidate the potentially complex governance characteristics of OSEI. The research reported in this thesis offers an integrated evaluation of community-led innovation in a complex social-ecological system. This reductionist approach proved to be effective at condensing the multifaceted, cross-scale nature of the subject and for which a quantitative approach was necessary. However, in order to explore in greater detail the more social and organisational aspects of OSEI, future work should seek to employ social network analysis, institutional analysis and qualitative studies into stakeholder perspectives and motives. The insight thereby derived may pave the way for a sustainable integration of socially innovative approaches to urban natural resource management.

### **7.6.1 Learning from OSEI design towards an approach to best practice**

Not only does social-ecological innovation demonstrate such potential but also, according to the nature of its occurrence, appears to be niche-oriented, finding place in the landscape where it will naturally be of most benefit. In this respect, OSEI appears to be akin to other kinds of human invention and evolutionary processes. The adaptability to circumstance inherent in its genesis is also desirable towards the creation of resilient social-ecological landscapes nurturing the adaptive capacity necessary to negotiate the, social and

environmental, challenges of the coming century. That said, it may be possible for the benefits issuing from OSEI to be achieved in a more sustainable and targeted fashion through the establishment of research-based best practice guidelines, improved social-ecological networks and the support, financial, administrative or otherwise, of local government and NGOs.

Accordingly, a greater understanding of the organisational nature of OSEI and the associated social networks in the landscape which may affect its distribution as well the continuation of its presence in the landscape, could be particularly advantageous in terms of ensuring the continuation and maximisation of the social-ecological benefits of OSEI.

Such attempts to standardise green space management based on examples of OSEI design would, however, benefit from further research into the transferability of certain characteristics of social-ecological innovation. For example, the analysis in Section 6.2.4 of this thesis demonstrated that site size played a significant role in terms of overall productivity (Table 6.4) with smaller sites having, from a spatial point of view, a relatively greater impact than larger ones included in the case study. Sites with smaller total area achieved a proportionally higher degree of productivity and the smaller size of these sites was largely a result of poor availability of green space. Such sites therefore naturally found their own niche in the urban landscape and the resulting impact, particularly from a green infrastructure perspective, may be potentially greater than approaches to OSEI which occur in areas of relatively higher ecological quality.

That said, it does not follow that multifunctional green space design should automatically seek small scale expression in the urban landscape, nor does it seem logical that, where larger areas of public green space may be available for the establishment of community-managed areas, numerous small sites would be advantageous to a smaller number of larger sites. Similarly, the value of small improvised pockets of ecologically viable urban spaces comes from their impact on pre-existing conditions (e.g. hundred percent sealing). It does not follow therefore that areas of high ecological value can be dismissed and replaced with developments on the rationale that they achieve, for example, a GI score of 0.6 as promoted by the BREEAM guidelines (see Section 5.2.1). From a purely ecological perspective, although larger sites in the study proved to be less social-ecologically productive, due to their size and location (primarily in parks, recreational green space and existing nature reserves), such areas benefit from lower human intervention and may provide havens for wildlife sensitive

to the high disturbance associated with more highly urbanised spaces. For this reason the protection of such spaces in urban areas, which also provide unique recreational opportunities for people, should be of primary importance in green space management. From a resilience perspective, although larger sites appeared to be less productive per unit area in terms of ecosystem services, they may provide valuable redundancy in the system and, as alternative low-impact management regimes, preserve important “slow” variables in the landscape such as habitat for biodiversity, pollination and soil formation. The case study in the current research appeared to reveal an optimal site size for ensuring reliable, efficient management and, therefore, productivity. Although, further research may help to clarify the kinds of configurations in the landscape in terms of size, type and distribution of OSEIs which provide the greatest promise of resilience for urban social-ecological systems.

Types of OSEI as described in this report presented a variety of design approaches which could, according to circumstance, be harnessed for the purpose of achieving specific goals. As mentioned earlier in this chapter, smaller site area appeared to lend itself to a more efficient rate of productivity, most likely by virtue of their being more easily manageable spaces and, as such, more readily intensified by human input. This was characterised by a negative correlation in the data between total site area and volunteer effort (Table 6.4). It would be unwise however to assume that sites, simply by virtue of their size, will yield predictable rates of productivity per unit area in terms of ecosystem services. For example, although the pocket park sites included in the case study were all below the average site size, community allotments (with the higher mean area of the two) were far more consistent in terms of productivity across all services in the assessment. This suggests that, although the case study assessment demonstrated that smaller sites were on the whole more efficient due to their size (Table 6.4), there are other management and environmental concerns that need to be considered when approaching the subject of site design. One such consideration is the element of access and security involved in site management. The type of OSEI which exhibited greatest consistency and evenness in ecosystem service provision, community allotments, consisted of sites all of which employed measures of security in their design, by way of secure perimeter fencing and limited access. Other sites which enjoyed high community input (volunteer hours) likewise used similar security measures (Fallowfield Secret Garden, Philips Park Community Orchard (Section 5.3.1)). Community allotments also exhibited the lowest degree of variation in terms of site area, which was close to the overall

mean for the case study (766m<sup>2</sup>). Therefore, design which combines similar elements in terms of site dimensions and access may provide a useful template as a basis for an approach to standardise, to some degree at least, multifunctional urban micro-scapes. As mentioned earlier however, such an approach may not be desirable, or achievable in all contexts. Highly urban spaces such as those found in the urban centre may not allow such extensive dimensions (but may benefit from added security measures given that these areas suffered from higher levels of crime). Conversely, in areas of extensive green space such as parkland or areas of green belt, site productivity may be less of a priority where a low-impact, extensive, rather than intensive, approach to management is desired for the sake of preserving more naturalistic landscapes.

### **7.6.2 Considerations relating to the standardising of innovation**

Attempts to support and disseminate the benefits derived from social-ecological innovation should take the importance of the social and ecological contexts of urban spaces into account. Moreover, any such attempt should also recognise that social-ecological innovation, like innovation of any kind, is always dynamic and responds to circumstances to the extent that its effectiveness is a result of bottom-up self-organisation by service-users themselves. Such organisation necessarily requires the flexibility which comes from informal arrangements regarding group structure and the freedom to make community-led decisions about communal urban spaces. Furthermore, the unchecked occurrence of OSEI in the urban landscape according to circumstance is accordingly non-uniform in its distribution (Section 3.2.2) which brings a welcome increase in the ecological heterogeneity in the landscape. Any attempt to organise social-ecological innovation from a top-down direction should recognise and mimic such happy consequences of an improvised approach to managing communal spaces. One consideration which would have to be included in working towards guidelines of best practice would be how to ensure the diversity and innovation inherent in OSEI whilst simultaneously highlighting and promoting design elements found to be commonly effective. Clearly the latter may lead to management uniformity and increasing connectedness in the network thereby reducing system resilience. For example, diversity of site management can occur at the micro-scale or the landscape scale. At the micro-scale, diversity in individual site design may provide a range of ecosystem services. However, if such site-level diversity were

to become standardised and widely promoted, this may, in fact, contribute to a uniformity in management approach at the landscape-scale, thereby reducing response diversity of the system. Similarly, the focus on specific services at site level may decrease overall productivity but contribute to a diversity in management at larger scales. Further research would be necessary to unpick the potential trade-offs and establish a desirable balance between management diversity and efficient production of ecosystem services.

Having a range of management approaches to OSEI in the landscape also appears advantageous from an adaptive cycle perspective. For example, different types of site management at different stages in the adaptive cycle may form mutually beneficial feedbacks. Allotment gardening is clearly a retainer of social-ecological memory related to food cultivation and has established efficient methods for optimising productivity from which newer, more improvised approaches such as pocket parks can receive important knowledge. In this way more consolidated, efficient management systems (in the *K* phase of the adaptive cycle) can inform newer innovations (in the *r* phase). Likewise the latter could provide examples of alternative, improvised design and management practices which, if adapted, could reduce the over-connectedness and homogeneity of the wider system thereby renewing their resilience and avoiding entry into rigidity traps.

Elements of site design such as layout, surfacing, materials, access and the inclusion of basic facilities are all of paramount importance at the micro-scale. Carefully planned site layout is fundamental in ensuring the maximum extent of both horizontal and vertical ecological intensification as well as providing basic facilities required for community involvement. Site access is also an important consideration when planning for long-term community management of sites. Those sites in the case-study which allowed free public access, either by necessity or design, proved to be less convincing in terms of community involvement (Section 4.4.6). It is likely the case that a certain degree of privacy and security allowed by limited access to appropriately enclosed sites are more attractive to communities. This is particularly relevant in the case of OSEI which occurs primarily in areas of high social deprivation where crime and anti-social behaviour may be a concern. Such a design, although potentially less visually integrated into the landscape, could ensure sustained community involvement as well as provide secure, sustainable hubs necessary for continuous educational, recreational and therapeutic activities.

What can be taken from the results of the case study, and applied universally to the design of multifunctional green space, is that sites which take food production as their staple practice, and thereby achieve a high degree of social and ecological intensification, appear to be consistently productive in terms of ecosystem services. Given that the case study sites in this thesis were universally committed to organic horticultural methods and closed-loop systems of food cultivation, OSEI may also bring associated benefits such as soil formation, improved fertility and biodiversity gains (Maeder et al., 2002; Tschardt et al., 2005; Kramer et al., 2006; Sandhu et al., 2010). As such an integration of OSEI, following these management principles may help foster the protection of those slow variables underpinning important regulating ecosystem services such as soil fertility, pollination, and nutrient cycling thereby enhancing ecosystem resilience (Biggs et al., 2012).

Careful design, in terms of structure, planting, crop rotation, stratification of crop cultivation, as employed in permaculture designs, and use of sustainable organic materials where possible (as demonstrated with particular effect in the case of Philips Park Community Orchard) would ensure the maximum social-ecological productivity of sites and increase the effect of positive feedbacks between community participation, as a cultural service in itself, and a range of associated ecosystem services. Moreover, the ecological intensification seen in examples of OSEI in this study, if applied more widely across areas of public green space, could make a considerable contribution towards achieving continuous productive urban landscapes and, in particular, climate smart, bio-diverse cities.

## **7.7 Concluding Remarks**

Three key findings of this research apply, in turn, to different scales and environmental management frameworks:

1. At the landscape scale, OSEI as a practice was a spatially conditioned phenomenon and resembled closely an adaptive response to a breakdown in social-ecological conditions. As such it was subject to the stages and traps of the adaptive cycle framework in social-ecological system and resilience theory.
2. At the micro-scale, OSEIs comprised multi-functional urban micro-scapes (MUMs) which were capable of producing simultaneously a range of urban-relevant



ecosystem services. Productivity was equally mediated by spatial (site size) and design considerations.

3. An emphasis on urban agriculture was instrumental: as a medium for OSEI in the landscape, as a synergistic mediating factor in the production of ecosystem services and as a social-ecological concern for urban residents. As such, food and the process of its cultivation represented a cross-scale theme, the analysis of which described in this thesis, effectively addressed the tenets of the three social-ecological management frameworks of resilience, ecosystem services and sustainability.

By providing evidence of the above, this thesis demonstrates in detail the social-ecological anatomy of an adaptive, civic green space management approach. As such the study provides empirical support, hitherto lacking, of the validity of such an approach and the considerations which affect that validity. Application of the recommendations herein could have considerable impact in terms of adding to the value and resilience inherent in urban social-ecological systems.

In terms of integrating OSEI in to the urban landscape, based on analysis of geographic context and site design, the following spatial model may provide a useful template for building on resilience in social-ecological landscapes: Table 7.1 describes a three-tiered approach whereby site design, drawing on lessons taken from OSEI distribution and productivity as presented in this thesis is tailored to specific urban contexts. The template mimics closely the distribution and design of OSEI as presented in the analysis in Chapters 4, 5 and 6 of this thesis. The highest degree of urbanisation provided the context for pocket parks which implied considerable social-ecological gains albeit constrained by low availability of functional green space. Such pockets of OSEI may, however, benefit from the added security provided by limited, managed access, given the generally high disturbance and crime prevalent in such contexts (Table 4.3). Moving further from the urban centre, where surface sealing becomes less extensive, multi-functional urban micro-scapes (MUMs) take a less improvised approach and greater site size allows for more sophisticated design including built structures, facilities and conditions more suitable to intensive food production. As such, site design can take on more multi-functionality as exhibited by community gardens and community allotments (Chapter 5). Effective levels of site security and a highly residential context encourage increased community input. A standard site size of approximately 750 –

1000m<sup>2</sup> facilitates reliable management intensity and associated production of ecosystem services as suggested in the analysis in Figure 6.10).

Finally, in areas of more extensive green space such as recreational land, municipal parks or green belt, the integration of sites of low-impact permaculture (SLIPs) could lead to the social-ecological intensification of the landscape without compromising pre-existing ecological conditions. By adopting a low-impact approach, as seen in the case of Birchfields Forest Garden and Stenner Lane Community Orchard (Section 5.3.1), sites are able to retain, and improve on, the naturalistic features of open green space, whilst generating productivity in terms of ecosystem services. The minimal approach of such agro-ecological design may contribute to the preservation of slower, underlying ecological processes which support a range of ecosystem services (UK NEA, 2011; Peters et al., 2013) and provide a buffer of larger, less intensively managed green space around the urban centre. Similarly, smaller sites which occur in more built up areas, but where space available to potential OSEI is greater than the optimal 750-1000m<sup>2</sup>, would benefit from incorporating less intensively managed site perimeters. Such “green peripheries” consisting of, for example, shrub or hedgerow may likewise provide a buffer to sites in terms of security, pollination and biodiversity and, if widely adopted, increase ecological connectivity in the broader landscape. This three-tiered approach is summarised in Table 7.1.

**Table 7. 1 Integrating green space management based on lessons from OSEI into the landscape.**

<b>Urban Context</b>	<b>Site design</b>	<b>Planning Considerations</b>
Urban centre	Pocket parks	Smallest scale (< 500m <sup>2</sup> ). Intensive design. Productivity may be enhanced through added security/ managed access.
Inner-city/Suburban	Multi-functional Urban Micro-scapes (MUMs)	Multi-functional sites (500 – 1000m <sup>2</sup> ). Focus on food production drawing on elements from provisioning types of OSEI. Polycultural planting schemes.
Peri-urban/extensive green space/parkland	Sites of Low-impact Permaculture (SLIPs)	Low maintenance, extensive site design (>1000m <sup>2</sup> ). Added security measures may enhance a sense of community ownership.

These recommendations can be further informed and validated through continued research into OSEI. The examples offered in Table 7.1 could however, if widely adopted, lead to a certain degree of standardisation and potential for over-connectedness in urban natural resource management. Given that perhaps the greatest strength of OSEI is the inherent freedom to innovate, the importance of such adaptive capacity to local conditions ought to be acknowledged and protected. For this reason, the most effective recommendation issuing from this research into social-ecological innovation may be the promotion and facilitation of community stakeholder leadership in local green space management. This would thereby

support the continuation of localised niche-driven management approaches. Such a decentralisation should be focussed on enabling access to potential sites as well as to resources, training and knowledge-networks. Such empowerment of local actor groups contribute more directly to the long-term creation of social-ecological memory and adaptive management of ecosystem services than would an imposed standardisation of green space management based on, for example, types of OSEI presented in this thesis. That said, access to information derived from this and other research would inform a collaborative approach between experts and stakeholders towards integrating multifunctional green space into the urban landscape in a way which supports diversity, functionality as well as redundancy towards long-term system resilience. Moreover, the effective diffusion of information, knowledge, contacts and skills throughout the social-ecological system, facilitated by local government and NGOs, may be the most intelligent intervention into civic ecological practices towards facilitating the effective, productive and diverse decentralisation of urban green space management.

To this end Table 7.2 summarises three areas of future work, at discrete scales, which may contribute to knowledge and adaptive capacity in social-ecological systems.

**Table 7. 2 Recommendations for Further Research.**

Scale	Research	Good Practice Considerations	Governance Approach
1. Landscape-scale	Detail actors, ties and distribution of information in social-ecological networks. Identify social-ecological “black-spots” and system “traps” in the landscape.	Facilitate distribution/diversity of social-ecological memory. Environmental education/out-reach.	Engagement with/recognition of local environmental actors. Subsidise supportive versions of OSEI.
2. Micro-scale	Increase body of case studies. Clarify effect of site design and ecosystem service provision.	Adopting effective and adaptive design and management over time.	Empower local stakeholders in green space management.* Remove obstacles to land procurement.**
3. Cross-scale	Monitor synergies and trade-offs between ecosystem services and management diversity.	Distribution of/access to knowledge and integration of functional diversity/redundancy.	Collaborative/polycentric natural resource management.

\*Through government funded training courses in e.g. i) horticulture/permaculture skills or ii) management/admin/financial skills.

\*\* Through e.g. i) free consultations/legal advice on land rights/rent and ensuring clarity and availability of rights and ownership or ii) facilitating flexible or government subsidised lease/rent agreements with private landlords and developers.

## Appendices

### Appendix One: List of OSEIs included in the Mapping Study (Chapter 4).

<b>OSEI</b>	<b>Postcode District</b>	<b>Food</b>	<b>Type</b>
1st Street	M1	No	Pocket park
Abundance Manchester	M20	Yes	Environmental resource project
Abundance Trafford	M16	Yes	Environmental resource project
ADS North	M16	Yes	Community garden
Affinty Allotment Gorton	M18	Yes	Community allotment
Action for Sustainable Living	M1	No	Environmental resource project
Age Concern Wythenshawe	M22	Yes	Community garden
Albermarle Allotments	M20	Yes	Community allotment
Balmoral Rd. Orchard	M41	Yes	Community orchard
Banky Meadows Fruit Woodland	M33	Yes	Community orchard
Barlow Moor Rd.	M20	Yes	Community garden
Baytree Residents	M9	Yes	Community garden
Biospheric Foundation	M3	Yes	Environmental resource project
Birchfields Forest Garden	M13	Yes	Community orchard
Bite	M15	Yes	Environmental resource project
Booth Centre	M3	Yes	Pocket park
Bowes St. Meanwhile	M14	Yes	Community orchard
Bridge 5 Mill	M4	No	Environmental resource project
Brighton Grove Community Plot	M14	Yes	Community allotment
Budding East Manchester Gardening Group	M11	Yes	Community garden
Buile Hill Park Community Garden	M5	Yes	Community garden
Buile Hill Garden Centre	M6	Yes	Community garden
Burnage Community Centre	M19	Yes	Community garden
Cawdor St, Walkden	M28	Yes	Community allotment
Centenery Garden	M16	Yes	Community garden
Chatterbox Green Fingers	M9	Yes	Community garden
Chorlton Community Wildlife Garden	M21	No	Community garden
Chorlton Good Neighbours	M21	Yes	Community garden
Church Street Planters	M4	Yes	Pocket park
Cranswick Square Triangle	M14	Yes	Pocket park

Crumpsall Community Allotment	M8	Yes	Community allotment
Dale St.	M1	Yes	Pocket park
Eat Your Streets	M16	Yes	Pocket park
Emerge	M11	Yes	Environmental resource project
Emerge Learning Garden	M11	Yes	Environmental resource project
Environment Network For Manchester	M4	No	Environmental resource project
Energise Project	M16	No	Community garden
Faith in the Community, Gorton	M18	Yes	Community garden
Faith in the Community, Cheetham Hill	M8	Yes	Community garden
Fallowfield Community Orchard	M14	Yes	Community orchard
Fallowfield Secret Garden	M14	Yes	Community garden
Feeding Manchester	M15	Yes	Environmental resource project
Fire Station Square	M5	Yes	Pocket park
Fog Lane Community Orchard	M20	Yes	Community orchard
Forgotten Fields	M15	Yes	Environmental resource project
Frenchbarn Lane	M9	Yes	Community allotment
Friends of Platt Fields	M14	Yes	Community allotment
Friends of St. Margaret's	M16	Yes	Community garden
Garden Needs	M7	Yes	Community garden
Grow In Broughton	M7	Yes	Community garden
Gorton Horticultural Society	M18	Yes	Community garden
Greengate Towerblock	M3	Yes	Pocket park
Grow For It, Chorlton	M21	Yes	Community allotment
Highfield Eco Allotment Project	M19	Yes	Community allotment
Horticultural Therapy Project	M8	Yes	Community garden
Hulme Garden Centre	M15	Yes	Environmental resource project
Incredible Edible Salford	M30	Yes	Community orchard
Irwell House Forest Garden	M3	Yes	Community orchard
Islington Estate	M3	Yes	Pocket park
Keeley Close	M40	Yes	Community garden
Kenworthy Community Orchard	M21	Yes	Community orchard
Kindling Trust	M15	Yes	Environmental resource project
Land Army	M15	Yes	Environmental resource project
LAWN project	M16	Yes	Pocket park
Leaf Street	M15	Yes	Community garden
Levenshulme Community Allotment	M19	Yes	Community allotment

Levenshulme Community Orchard	M19	Yes	Community orchard
Little Hulton Men's Group	M38	Yes	Community garden
Longford Park Community Allotment	M32	Yes	Community allotment
Lost Plot	M21	Yes	Community allotment
Manchester Permaculture	M15	Yes	Environmental resource project
Manchester Refugee Support Centre	M14	Yes	Community garden
Manchester Environmental Education Network	M4	No	Environmental resource project
MERCi	M4	No	Environmental resource project
MIND/Community Larder	M3	Yes	Pocket park
Mirfield Road Community Garden	M9	Yes	Community garden
Moss Side Community Allotment	M14	Yes	Community allotment
Moss Side Peace Gardens	M14	Yes	Community garden
MPCG	M4	Yes	Community garden
Old Moat Gardeners	M20	Yes	Community allotment
Orchard 49	M16	Yes	Community orchard
Ordsall Community Allotment	M5	Yes	Community allotment
Pear Tree Court	M6	Yes	Pocket park
Philips Park Orchard	M11	Yes	Community orchard
Phoenix Community Garden	M15	Yes	Community garden
Planting and Learning Old Trafford	M16	Yes	Community allotment
Raddisson Roof	M2	No	Pocket park
Regenesis Garden	M16	Yes	Community garden
Ridgeway Community Garden	M4	Yes	Community garden
Rosehill Community Farm	M22	Yes	Community allotment
Rutland Avenue Residents' Association	M20	Yes	Community garden
Silver Service	M20	Yes	Community garden
Sustainable Neighbourhoods Action Group	M4	No	Environmental resource project
Southlea Community Gardens	M20	Yes	Community garden
Sow the City	M19	Yes	Community allotment
St. Mark's Food Group	M22	Yes	Community allotment
Start in Salford	M6	Yes	Environmental resource project
Stenner Lane Orchard	M20	Yes	Community orchard
Sale West Community Garden Group	M33	Yes	Community garden
Syrian House	M33	Yes	Community garden
Tang Mere Court	M16	Yes	Community garden
The Addy Centre	M22	Yes	Community garden



The Big Dig	M15	Yes	Environmental resource project
The Limes	M14	Yes	Community garden
The Valley	M27	Yes	Community allotment
Thomas St. Pocket Park	M4	Yes	Pocket park
Tindle Allotment	M30	Yes	Community allotment
Trafford Organic Growers Network	M16	Yes	Environmental resource project
Walled Garden Project	M22	Yes	Community allotment
Whitworth Gallery	M15	No	Pocket park
Woodhouse Park	M22	Yes	Community allotment
Wythenshawe Community Farm	M23	Yes	Community garden
Zion Centre	M15	Yes	Environmental resource project

**Appendix Two: GI Toolkit (GINW, 2010) calculation sheet (Microsoft Excel, 2010). Worked example: Planting and Learning Old Trafford.**

<b>Site area (m<sup>2</sup>)</b>				<b>950.0</b>
<b>Non-overlapping surface types</b>		<b>GI Factor</b>		<b>Area (m<sup>2</sup>)</b>
A1	Buildings (without green roofs)	0.0	x	0.0
A2	Buildings (with green roofs). N.B. Please only include the area of the roof that is covered by vegetation here. If part of the roof is not vegetated include it in A1).	0.7	x	0.0
B1	Non-permeable road surfaces	0.0	x	0.0
B2	Non-permeable footpath surfaces	0.0	x	0.0
B3	Roofs draining on to vegetation/rainwater harvesting	0.2	x	63.0
B4	Semi-permeable surfaces such as stone paving with joints (where water can infiltrate)	0.2	x	59.5
B5	Semi-permeable surfaces such as gravel	0.4	x	245.5
C1	Vegetated or open soil surfaces (where plants have direct contact with deeper soil)	1.0	x	556.0
C2	Vegetated or open soil surfaces (where soil depth is more than 60cm but there is no direct contact with deeper soil; e.g. roof of underground parking). N.B. Please do not use this for green roofs on buildings - use A2 instead.	0.6	x	16.0
C3	Vegetated or open soil surfaces (where soil depth is less than 60cm and there is no direct contact with deeper soil; e.g. roof of underground parking). N.B. Please do not use this for green roofs on buildings - use A2 instead.	0.4	x	0.0
D	Open water surfaces (including ponds and swales covered by water for at least 6 months of the year)	1.0	x	10.0
<b>Total area entered (m<sup>2</sup>)</b>				<b>950.0</b>
<b>Overlapping surface types</b>		<b>GI Factor</b>		<b>Area (m<sup>2</sup>)</b>
E	Shrubs and hedges. N.B. Should not exceed development site area. Can overlap surfaces A1-D and F.	0.3	x	15.0
F	Trees (canopy cover area). N.B. Should not exceed development site area. Can overlap surfaces A1-D and E.	0.4	x	10.0
G	Green walls (area up to a height limit of 10 m)	0.6	x	0.0
Ecologically effective area (EEA) =				<b>698.3m<sup>2</sup></b>
<b>GI Score (EEA/Site area) =</b>				<b>0.74</b>
				<b>“Very Good”</b>

**Appendix Three: Case study site GI score calculations.**

Surface Type	GI factor	Site area (m <sup>2</sup> )											
		Centenary	FSG	BMRCG	PLOT	MSCA	GFIC	SLCO	BFFG	PPCO	Triangle	Dale St.	HCGC
A1	0	0	0	0	0	0	0	0	0	0	6	0	0
A2	0.7	0	0	0	0	0	6	0	0	0	0	0	0
B1	0	0	0	0	0	0	0	0	0	0	5	0	0
B2	0	0	0	0	0	0	0	0	0	0	0	60	3
B3	0.2	79.5	53	0	63	28.5	42.5	0	0	12	12.5	0	0
B4	0.2	91	0	0	59.5	149	234	0	0	0	45	0	24
B5	0.4	280.5	289.5	30	245.5	73	0	0	0	0	55	55	76
C1	1	485	1114	530	556	517.5	345.5	1044	1734	362	78	33	69
C2	0.6	0	73.5	0	16	0	0	0	0	0	13.5	73	10.5
C3	0.4	0	0	0	0	0	2	0	0	0	0	0	34
D	1	0	0	0	10	12	0	0	0	6	0	0	0
E	0.3	24	19	15	15	26	15	0	383	38	32	0	10
F	0.4	60	60	21	10	35	39	365	350	190	10	13	7
G	0.6	0	0	0	0	0	0	0	0	0	0	0	0
EEA*(m <sup>2</sup> )		665	1316	554	703	616	422	1190	1994	456	133	104	130
Total area (m <sup>2</sup> )		936	1530	560	950	780	630	1044	1734	380	215	221	217
GI score		0.71	0.86	0.99	0.74	0.79	0.68	1.14	1.15	1.20	0.62	0.47	0.60

\*Ecologically effective area.

Site Key: FSG = Fallowfield Secret Garden, BMRCG = Barlow Moor Road Community Garden, PLOT = Planting and Learning Old Trafford, MSCA = Moss Side Community Allotment, GFIC = Grow For It Chorlton, SLCO = Stenner Lane Community Orchard, BFFG = Birch Fields Forest Garden, PPCO = Philips Park Community Orchard, HCGC = Hulme Community Garden Centre.

**Appendix Four: Food Yield Proxies: Calculation Tables.**

**i) Vegetable Yields (Philadelphia Harvest Report: Vitiello and Nairn, 2009).**

Site area	No. gardens	Total crop area (ft <sup>2</sup> )	Crop area (m <sup>2</sup> )	Yield (lbs)	Yield (kg)	Yield (kg m <sup>-2</sup> )
1 - 5 acres	3	64713	6012	91892	41681	<b>6.93</b>
0.5 - 1 acre	8	125337	11644	177979	80730	<b>6.93</b>
0.25 - 0.5 acre	20	123753	11497	175729	79709	<b>6.93</b>
1000 - 10000 ft <sup>2</sup>	161	146381	13599	207861	94284	<b>6.93</b>
< 1000 ft <sup>2</sup>	31	12223	1136	17357	7873	<b>6.93</b>

**ii) Fruit yields (UK horticultural statistics dataset: Defra, 2013)**

UK national trade values 2007 – 2011 (Defra, 2013)	Year					5-year mean
	2007	2008	2009	2010	2011	
<b>Total Orchard Fruit :</b>						
Planted area (hectares)	18,069	18,620	18,777	18,934	19,214	
Yield (thousand tonnes)	282.19	270.93	268.92	286.04	291.81	
Yield (kg m <sup>-2</sup> )	<b>1.5618</b>	<b>1.455</b>	<b>1.43219</b>	<b>1.51077</b>	<b>1.51877</b>	<b>1.50</b>
<b>Total soft fruit:</b>						
Planted area (hectares)	9,207	9,422	9,627	9,683	9,710	
Yield (thousand tonnes)	118.06	130.94	138.88	138.27	136.79	
Yield (kg m <sup>-2</sup> )	<b>1.2824</b>	<b>1.3897</b>	<b>1.44254</b>	<b>1.42803</b>	<b>1.4088</b>	<b>1.39</b>

**Appendix Five: Food production calculation table.**

Site	Site Area (m <sup>2</sup> )	Vegetables (m <sup>2</sup> )	Soft Fruit (m <sup>2</sup> )	Hard Fruit (m <sup>2</sup> )	Veg. Yield (kg)*	Soft Fruit Yield (kg) <sup>†</sup>	Hard Fruit Yield (kg) <sup>‡</sup>	Total Yield (kg)	Yield (kg 100m <sup>-2</sup> )
Centenery	936	14	10	12	97	14	18	129	14
FSG	1530	80	0	0	555	0	0	555	36
BMRCG	560	62	33	6	430	46	9	485	87
PLOT	950	350	40	13	2427	56	20	2502	263
MSCO	780	300	0	20	2080	0	30	2110	271
GFIC	630	150	25	20	1040	34	30	1104	175
SLCO	1044	0	0	260	0	0	390	390	37
BFFG	1734	0	200	352	0	278	528	806	46
PPCO	380	60	0	200	416	0	300	716	188
Triangle	215	14	15	5	97	21	8	125	58
Dale St.	221	85	0	15	586	0	23	608	275
HCGC	217	29	0	0	199	0	0	199	92

\* Vegetable cultivation area (m<sup>2</sup>) x 6.93kg (source: Vitiello and Nairn, 2009).

† Soft fruit cultivation area (m<sup>2</sup>) x 1.39 (source: Defra, 2013)

‡ Hard fruit cultivation area (m<sup>2</sup>) x 1.50 (source: Defra, 2013)

Site Key: FSG = Fallowfield Secret Garden, BMRCG = Barlow Moor Road Community Garden, PLOT = Planting and Learning Old Trafford, MSCA = Moss Side Community Allotment, GFIC = Grow For It Chorlton, SLCO = Stenner Lane Community Orchard, BFFG = Birch Fields Forest Garden, PPCO = Philips Park Community Orchard, HCGC = Hulme Community Garden Centre.

Type key:

community gardens
community allotments
community orchards
pocket parks

**Appendix Six: Biodiversity Data Recording Sheet**

	Site Percentage Cover	
	North	South
<b>Site name:</b>		
<b>Domin Layer</b>		
<b>Upper tree layer &gt; 10m</b> Conifer/Broadleaf/Mixed		
<b>Lower tree layer 4 - 10m</b> Conifer/Broadleaf/Mixed		
<b>Bush layer 1 - 4m</b> Shrub/Scrub/Hedgerows		
<b>Field Layer 20cm - 1m</b> Low bush/Grasses/Herbs		
<b>Lower herb layer 5cm - 20cm</b> Cropped/Mown grassland/Road verges		
<b>Ground layer &lt; 5 cm</b> Bare ground/Bryophytes/ Funghi/ Lichens		
<b>Aquatic type</b> Lake/River/Pond		
<b>Built</b>		
<b>Vascular plant genera total:</b>		
<b>Characteristic species:</b>		

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