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THE EDIBLE URBAN LANDSCAPE

An Assessment Method for Retro-Fitting
Urban Agriculture Into An Inner London Test Site

Abstract

The Edible Urban Landscape:
An Assessment Method for Retro-Fitting Urban Agriculture Into An Inner London Test Site

This thesis explores the practice called urban agriculture (UA), which attempts to cut down on urban food and non-food imports, by growing crops and products on land in and around cities. The practice is wide spread and ultimately necessary in many of the expanding cities of the developing nations, to ensure food security.

However, the prescriptive nature of UK planning laws leaves little, if any room, for self-organised UA practices to evolve, hindered further by the fragmented and undocumented nature of urban green space planning.

This thesis has developed a method, based around Geographical Information Systems (GIS), for retro fitting, measuring and evaluating, a vegetable growing, UA system, which could be integrated into green urban space. The results of the method should be in a format which makes them quantifiable for both architects and planners, so that UA food systems can be considered as a form of renewable energy, along side wind or solar.

This method will be tested in three central London locations. The results were evaluated, relative to their yields per square metre, how they would feed the surrounding population and the CO_2 emissions saved on reduced food miles and by eliminating the need to maintain some grasser areas.

The results show that the central London test areas, together with its surrounding environs, are rich in traditional, as well as undocumented open space and that the conversion of 26% of this space to UA practices, could provide 27% of the daily vegetable requirements over a 259 growing period. The method established a ratio of yield of vegetables, per square meter per person, which would be suitable for architects and planners to incorporate into urban planning.

The impact on CO_2 from food miles and ground maintenance equipment, was quantifiable but not conclusive, therefore a more comprehensive system of measuring emissions needs to be adopted for further work.

Key words: Urban Agriculture, Geographical Information System, food miles, CO_2 emissions, Parks, grass, landscape, energy, density, yields.

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Contents

List of Tables, figures and illustrations

List of Acronyms

ANAP	Asociación Nacional de Agricultores Pequeños (Cuba)
CAP	Common Agricultural Policy
CHP	Combined Heat and Power plants
CO_2	Carbon Dioxide
CPULs	Continuously productive Urban Landscapes
DEFRA	Department for Environment, Food and Rural Affairs
EPA	Environmental Protection Agency (USA)
GHG	Green House Gas Emissions
GIS	Geographical Information Systems (or Science)
Gj	Giga joule
GLA	Greater London Authority
Gha	Global hectares
Ha	Hectare
Kg	Kilogram
Km	Kilometre
LCA	life cycle analysis
M^2	Square metres
MDG	Millennium development Goals
NSALG	National Society for Allotments and Leisure Gardens
OS	Ordinance Survey
PFAF	Plants for a Future
POE	Post Occupancy Evaluation
PPGIS	Public Participatory Geographical Information Systems (or Science)
RHS	Royal Horticultural Society
SINC	Sites of Interest for Nature Conservation
WASD	Weight Average Source Distance
UA	Urban Agriculture
UPA	Urban and peri-urban Agriculture
UDP	Unitary Development Plan
UNDP	United Nations Development Program
UK	United Kingdom

Chapter 1
Introduction

1.0. Trafalgar Square

> "We came presently into a large open space, sloping somewhat towards the south, the sunny site of which had been taken advantage of for planting an orchard, mainly, as I could see, of apricot trees…from the southern side of the said orchard ran a long road, chequered over with the shadow of tall old pear trees, at the end of which showed the high tower of the parliament House, or Dung Market" (Morris, 1890)

This description of London, from William Morris's News from Nowhere describes a city full of productive urban spaces, where all the trees are fruit trees and the Houses of Parliament are used as a dung market for the sale of manure. While News from Nowhere can be read as a self-styled piece of Utopian, Anarchist romanticism, it can also be seen as an attempt to create a vision of our vast capital that welcomes agriculture, wildlife, where there is no distinction between the urban townscape and the rural countryside; to Morris it is a single idea of landscape.

He is not alone in this vision. In 1996, the United Nations Development program published Urban Agriculture: Food Jobs and Sustainable Cities (UNDP, 1996). The UN document brought together a range of research into the practice of growing food in cities, or "urban agriculture" (UA) and placed it within the contemporary debate about climate change and the rapidly increasing urban population together with their dependent on imported foods from the fossil fuelled agro-industries. Although UA practices vary from country to country and between cities, there are common goals, including food security (Rees 1997) and independence (Gaynor 2006), access to fresh produce (Viljoen et al, 2005) and economic necessity for rural migrants (UNDP 1996).

As a highly developed country the UK is almost completely dependant on imported foods (Best Foot Forward, 2002), and has no UA national policy (Howe and White 2001). For UA to arise within the UK, the practice would either have to circumvent its highly prescriptive planning laws, or develop urban food production as a technology, that can connect with those professions that concern themselves with the urban project.

This thesis will develop and test *a method for retro fitting UA into a central London location*. The method will concern itself with measuring green urban space, developing a set of results which can be integrated into the discourses of architecture, planning and the continuing debate around sustainable cities. This will allow UA to be considered by policy makers, designers and individual organisations, as a quantifiable option when designing green space for cities. Calibrating UA in this way, and specifically food yields to density, will bring food alongside other renewable energy sources such as wind, solar or CHP. Below is a summary of the key statements and questions:

- Do we have enough land in our urban centres to support UA?
- Can a method be developed to enable food to be seen as a renewable energy?
- The consideration of grassed or open land a key resource of that renewable energy
- Can UA production be embedded into planning and architecture?
- The method developed, has to relate yields to surrounding density

2.0. Landscape

In order to understand why food production is clearly absent from UK cities, except in the recreational format of the allotment, chapter 2 will outline the development of urban green space within UK, from the 19th century onwards. It will show how the integration of agriculture and city, so important to our development, was replaced by the dichotomy of the rural/urban split as food production was gradually removed and defined as an occupation outside of the city. Its replacement, the formal park, garden or square, became a mirror of the architectural aesthetic that surrounds it. Finally, the division of urban as consumption from rural as production was set in place by the green belt, which signalled the ultimate segregation of city from its hinterland.

The chapter will close with an explanation of how our understanding of urban green space has not developed since the inception of the first public park in Derby, 1840. This has lead to stagnation in our definition of the purpose of urban green space and its ecology, leaving it ill defined, beyond recreation and leisure activities. Finally, an analysis of the energy required to maintain the mown urban landscape will be undertaken, so that calculation can be made about how UA practices might affect emissions associated with current grounds-maintenance regimes.

3.0. The Urban Ecosystem

Moving on from this, Chapter 3 will look at how the urban environment developed an ecological identity of its own, requiring a huge increase of imports, as its numbers swelled over the 20th century. The chapter argues that, in the case of food, there is an inherent contradiction in a process that expands more energy to grow, process, pack, transport and dispose of the relevant waste, than is actually available in the food product when eaten. The contradiction is concealed by the use of non-renewable energy sources, in the form of fossil fuel, creating an agricultural industry that is unsupportable without it.

The chapter will argue that central to the urban food chain is transport, or 'food miles', which describes the increasingly long distances food travels until it reaches the point of sale. These food miles are rapidly becoming a key contributor to the UK's Green House Gas (GHG) emissions, with air freighting of fresh vegetables, often from Africa, contributing the most pollution. The chapter will define a simple food-miles table for use in the UA evaluation method developed in chapter 6.

4.0. The UA Landscape

In chapter 4, UA practices will be defined and discussed, arguing that they are a viable alternative to the food-miles system. Chapter 4 will also provide an overview of UA practices, both historically and worldwide, with an in-depth look at UA in China, Eastern Africa, Cuba and Australia.

From this, an understanding of the efficiency of UA practices will be analysed, with a close look at micro-agricultural systems, together with their potential yields relative to the space they consume. From this, a potential yields per hectare can be established so that the UA site in chapter 6 can me tested against its relationship to the local population.

5.0. UA in the UK

Chapter 5 will look specifically at how UA has been practised, as well as hindered, within the UK, with a brief look at the Garden City movement, as well as a review of current research on the possibility of growing food in UK cities, together with methods for quantifying urban space. Following on from this, the chapter will look at Geographical Information Systems (GIS) - a digital tool used for mapping that can combine quantitative as well as qualitative data. GIS is steadily becoming the preferred system, among many organisations, for collecting spatial data.

The section will conclude with a brief review of the way GIS has been used within UA practices and how this thesis will adopt GIS as it main tool for measuring green spaces within London.

6.0. Primary Data Collection

Chapter 6 will bring together the four main elements of the preceding chapters and outline the methodology and research design for the UA assessment method. The four main elements of the methodology are:

- Measuring urban green space
- Quantifying yields of vegetables per hectare
- Relating them to the surrounding density
- The effect on CO_2 emissions from food miles and ground maintenance

The research design adopts a seven-stage investigation, combining quantitative as well as qualitative investigations of a 191.34 hectare site in central London. Two other test sites, measuring 23.11ha and 107.36ha, were also looked at so that some comparison could be made between the data obtained. These secondary sites did not use the full seven stages of the method and were analysed from satellite and Ordinance Survey (OS) data alone.
The seven stages are:

- **1 Digital map creation,** creating a digital map of the potential UA area so that roads, buildings and open space can be clearly identified.
- **2 Quantitative and qualitative data collection,** satellite imagery is compared OS data
- **3 Division of urban spaces,** using qualitative and quantitative data, into their various cover types.
- **4 Inserting UA units into the landscape**, so that the existing use, where it is evident, can continue.
- **5 Assessing yields**, relative to the surrounding density.
- **6 Comparing UA with current food imports models** (food access maps) together with grounds-maintenance equipment and their possible effect on CO_2 emissions.
- **7 Presenting results**, analysis and feedback of these findings into the original GIS stream.

7.0. Results and Analysis

Chapter 7 will present the results of the method, together with an analysis of the implication, relative to the subject areas outlined at the start of chapter 6.

8.0. Conclusion

The conclusion will highlight the successes and failures of the method developed. Chapter 9 will suggest further work on both the method and the subject area.

Chapter 2
Definitions Of Landscape

2.0. Introduction

This chapter will explore the relationship between agriculture, horticulture and the city. Discussing how they became separated through the urban/rural dichotomy and the placing of the city as our preferred urban leisure landscape.

2.1. The Rural and the Urban

Although it is culturally acceptable to talk about the rural landscape and the urban landscape (Harper, 2001) as two distinct environments - the former as a man-made construct; the latter as a product of nature - these are relatively recent definitions and their distinctions are caught up in the romantic and cultural mythology of England and the British Isles. Moreover, as illustration 1 shows, the English rural landscape is far from natural and has been subject to man's intervention since the medieval period (Mabey, 1980).

Illustration 1: The Fens, England

The Ghost of the Natural River Path against the Straight Drainage Channels

Source: Muir, 1983

For example, as early as 1230, deforestation in England had become so intense that it caused the first imports of timber into Grimsby Harbour from Scandinavia (Gimpel, 1977).

Furthermore, food production was something that was integrated into the fabric of the city. The idea of growing food at increasing distances away from cities is a modern phenomenon, particularly of post-war agriculture. Jane Jacobs argues (Jacobs, 1969) that the development of cities actually invented productive agriculture. Her reasoning is based on the fact that most agriculture would not have developed without trade, resources and technical innovation that came from cities (Jacobs 1969, Astill and Langdon, 1997, Duby, 2000). By bringing food production back within the city, we are simply acknowledging the reasons why cities developed and succeeded in the first place.

2.2. First Public Park

Between 1882 and 1909, as the urban centre of London grew, over half a million acres of farmland were converted to industrial, housing or transport (particularly railways). This absorbed any over-population of the countryside, creating an increased demand on agricultural production (Duby, p.128)

As agriculture left the city, its open spaces were filled with the new ideas of landscape architecture[1] and garden design. In England, it was John Claudius Loudon who championed the phrase landscape architecture, and defined this new art-form in the 1829 edition of Gardeners Magazine, which he edited. He wrote that the new idea of Arboretum should be defined as

> "a landscape composition of wood, water and turf; secondly, as an assemblage of trees for botanical and pictorial study… It should also be an imitation of natural scenery, or a composition with a view to create a character of art" (Loudon, 1829, p.344)

Loudon layout the first public park or Arboretum in Derby in 1840[2], on private land owned by Joseph Strutt[3] and his 'invention' of the public urban park is a model still recognisable today. Although the park charged a small fee for five days of the week, it was free of charge for two days, one of them being Sundays. However, in keeping with the idea of improving the general spirit of the urban working class (Hough, 1995, p.183; Chadwick, 1966, p.63), the Sunday opening hours were restricted to allow for potential visitors to still attend church[4].

Thus the public park, as the consolation prize offered to both the new urban proletarians and the new urban city, became not only part of the urban planning structure, but also part of a drive towards improvement both in health and education of the inhabitants. As the report by the 1833 Select Committee on public walks states, "It cannot be necessary to point out how requisite some Public Walks or Open Spaces in

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1: The term landscape architecture, was first used by Gilbert Laing Meason in 1828

2: Derby was followed by Nottingham in 1852, Lincoln in 1868, and Walsall in 1874

3: Christopher Harris states" The Arboretum was built on land once owned by the King…The area known as "The Liberty of Litchurch" and was sold by the crown to private owners such as Wilson and Leacroft, from whom Joseph Strutt purchased 11 acres. Strutt designed and laid out a private garden for himself and his family on this 11 acres. It is this land which he commissioned Loudon to draw up a plan to convert it into a public garden for the purposes set out by Strutt in 1839". Personal communication, Christopher Harris. Email: derby.arboretum@ntlworld.com

4: While Regents Park, opened in 1838, slightly predates the Derby Arboretum, what distinguishes them, is their motivations. Regents Park was part of the great royal parks and estate projects, that can be seen in its infancy at Hampton Court , laid out in 1515 and culminating in Nash's final design for Regents Park. However, in contrast to Derby, the Regents park development had exclusive entry criteria which necessitated being "a man of fortune and take exercise on horse back, or in a carriage" (The Park in the Town, p 320).

the neighbourhoods of large towns must be; to those who consider the occupations of the working class who dwell there." (Slaney, 1833)

Illustration 2: Derby Arboretum, the First Public Park

Source: Harris, C., (2006), *Derby Arboretum*

2.3. The Leisured Landscape

Loudon's style became known as the "picturesque"[5] and attempted to capture a 'natural' look to landscaping, and illustration 3 shows the vast lengths that bhis designs went to. The 'natural look' rapidly disappearing under the plough as common land and community strip farms were enclosed to form larger, regular enclosed farms; Loudon's response was to fake it.

Illustration 3: Landscape Transformed - Before and After Loudon

Source: Berrall, 1978

However, garden design was not an exact science but a "hybrid medium"[6] of painting, architecture, natural history, engineering and hydraulics (Mosser and Teyssot, 1991). It was a marriage of nature with culture:

> "'natural' is the cultural meaning read into nature, meaning determined by those with power and money to use nature instrumentally, as a disguise, as a subterfuge, as a pretence that things were always thus, unchangeable and inevitable (Pugh, c.1988, p.2)."

5: Loudon's ideas of landscape are a development of the earlier work of such figures as Lancelot "Capability" Brown (1715 -1783) and later Humphrey Repton (1752-1818).

6: Hegel, In the introduction to Aesthetics. Describes, Garden design as a "hybrid… which while falling short of perfection… does not lack merit or… charm"

The manipulation, transformation and control of landscape was now happening on an immense scale, with a well-reasoned ideology, which would later be institutionalised as the Architecture Act of 1834, followed by planning in 1913. Both these acts turned the decisions about the design of landscape, over to professional bodies, separating them from the newly dispossessed urban population. Alison Ravetz (1986) argues that through the use of scientific doctrines, planning once established as a professional discipline, was made unchallengeable[7]. The culmination of this process was the Town and Country Planning Act of 1947, which effectively meant that both the infrastructure (planning) and superstructure (architecture) of the landscape could no longer evolve from the ground upwards (Ravetz, 1986).

2.4. The Green Belt

The separation of town and country was fully realised in the green belt scheme in 1935, shown in illustration 1939, followed by the Green Belt Act of 1938 (Ward and Hardy, 2004). The purpose of this act was to contain the city within a set boundary, while at the same time safeguarding access to the open countryside for the city dweller.

Illustration 4: Green Belt Exhibition 1939

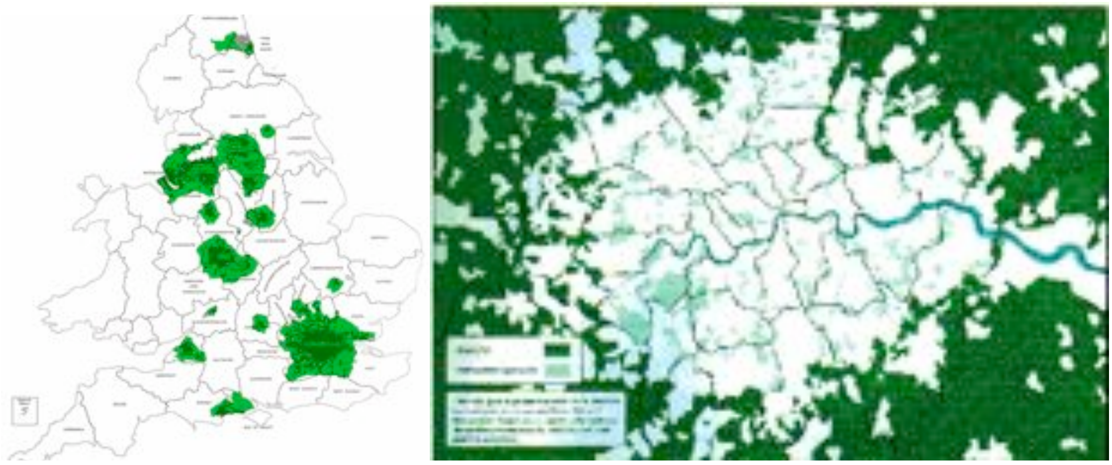
Source: Saint, 1999

However, it also created a physical split between the urban and rural, between the food production of the countryside and the growing consumerism of the city. The green belt not only kept the city out of the countryside but also kept the countryside out of the city, an "unholy, unnatural separation of society and nature" (Nicholson-Lord, c.1987). Perhaps this is why, with the exception of the allotment acts of the early 19th

7: The motivation for planning control wasn't simply the consolidation of power; decisions were taken on public health grounds (Public Health Acts, 1848 and 1872) and to improve the housing available to working-class families (Housing of the working class act 1885, 1890), as city populations exploded during the 19th century.

century, the term urban agriculture has become an oxymoron for town planners, with the assumption that it requires the turning of parks into corn fields.

Illustration 5 The Green Belt: Left - England, Right - London.



Source: http://www.bartlett.ucl.ac.uk/planning/information/texts/pil.htm

Despite the 1887 and 1908 allotment acts, city food production was forever doomed to become a compromise, a consolation and an icon of the demise of urban productivity, while the parks were to establish themselves as “adjuncts of the city, an extension of its planned and constructed fabric: hence the emphasis on the ornamental, the architectural and the sculptural, all aspects of the city as artefact” (Nicholson-Lord, c.1987, p.30).

Illustration 6: Moor House, City of London, the Artificial and the Ornamental

Source: The Author, 04/05/06

2.5. Totality of Planning

As the 19th century came to a close, “the mown turf of our parks, the municipal flowerbeds and castrated ornamentals of our planned green urban spaces” (Hough, 1995), a marriage of “the aristocratic and the bourgeois, the country house and the suburban villa” ruled the planned architecture of the city.

Illustration 7: Golden Square, London. The Ornamental Architectural Urban Landscape

Source: The Author 10/05/06

As shown, the idea of the park within the city, as a replacement for the slow removal of agriculture, was not an isolated aesthetic event, and therefore should not be judged purely on visual terms. It was the manifestation of a long historical process, involving a complex relationship between authoritarian ideology, economic process, and rapid social change, as England went from a rural population in 1800 to an urban population in 1900[8].

Nonetheless, of concern here is not simply that the government of the day decided to take control of the space around its citizens, or that planning the landscape, often with a combination of public, private and government organisation was becoming the norm, but that there was a clear methodology at work, when it came to making decisions about architecture and landscape. In 1977, Michel Foucault described public urban building schemes as the "spatial nesting of hierarchized surveillance" (Foucault, 1977. p.171). For Foucault, these schemes were not the hallmark of a "triumphant, omnipresent, power", in the same vein as "the majestic rituals of sovereignty or the great apparatuses of the state". Instead, the organisations that sought to plan our urban space were a "modest, suspicious power, which functions as a calculated, but permanent economy", that seeks "gradually to invade the major forms, altering their mechanisms and imposing their procedures" (Foucault, 1977, p.171).

These procedures, together with the gradual removal of the productivity of the urban landscape were perhaps simple to impose on a 19th-century population with a life expectancy of only 40 (White, 2002). Memory would change rapidly with each new generation, so that soon, a new urban class would be born that would have no knowledge of anything other than an urban environment, together with its architecture,

> "that would operate to transform individuals: to act on those it shelters, to provide a hold on their conduct, to carry the effects of power right to them, to make people docile and knowable" (Foucault, 1977, p.172).

The influence of the urban form, also influenced the how nature interacts with the city; As Emile Zola states, when he describes the grassed public squares of Paris: "It looks like a piece of nature that did something wrong and was put in prison" (Hollier, 1992, p.xv) See illustration 8.

8: During World War I and the inter-war period, agriculture and forestry, having been in decline during the end of the 19th century, came under intense pressure to increase output (8). The 'agricultural revolution' of the inter-war years, caused mainly by mechanisation, was counter-balanced by the view that the countryside should also be a place of leisure for the growing urban population. John Dower, the father of the idea of national parks, spoke in 1943 of the need to give "physical, mental and spiritual health and happiness to 'the whole mass of the people'" and between 1951 and 1957, ten national parks were designated, followed by 19 areas of outstanding natural beauty .

Illustration 8: Keep Off The Grass, Canary Wharf, London

Source: The Author, March 2006

2.6. Lawns and Energy Use

One of the legacies of the urban park is the monoculture of grass that fills even the smallest urban space. Of concern here is the inefficient use of small two-stroke and diesel engines used in mowing and general lawn-care products, which are not covered by emissions regulations. A large municipal lawn mower, such as the Commander 3520 shown in illustration 9, produces 1990 g/ CO_2 per km[9], compared with 166 g/ CO_2 for the Ford Focus (see appendix 4)[10]. It has been estimated that fossil fuel mowers add 1500 times more carbon monoxide, 31 times more hydrocarbons and nitrogen oxides and 18 times more carbon dioxide than electric varieties (Hoover, 2005).

Illustration 9: The Commander 3520, Burgess Park. April 2006

Source: The Author. April 2006

Table 1 shows the emission figures for the Ransomes Commander 3520 together with a calculation of 7805.3 grams CO_2 per hectare of the expected CO_2 emissions that could be saved by replacing grass with UA units (see appendix 1 for technical data on the Ransomes Commander 3520). The figured was arrived at by using the online emissions calculator provided by Environmental Technology Centre, for the Canadian Environment agency (Environment Canada 2005). This figure will need to be extrapolated over the grass cutting season which is twice a month, from March to September.

9: Data supplied by: http://www.ransomesjacobsen.com/product_details.php?id=26 (accessed 27/03/06)
10: Data supplied by: http://motoring.independent.co.uk/road_tests/article844543.ece (accessed 28/03/06)

Table 1: Emissions from Grass-Cutting. Commander 3520

Manufacturer	Model
Ransomes-Jacobson	Commander 3520
Performance	
3.2 ha/hr at 12.5 km/hr	
Emissions and Consumption	
Cutting Cycle	1992.9 grams CO_2 per km
Fuel Consumption (cutting cycle)	40.50 litres per 100km
Emissions per hectare	7805.3 grams CO_2

Source: www.ransomesjacobsen.com (see appendix 1)

On top of this, grass, while providing a valuable social amenity, does in fact hinder the potential for biodiversity (Shochata *et al*, 2006), and uses vast quantities of water. It has been estimated that the average US city uses between 30 – 60% of its fresh-water supply on grass maintenance (Bormann *et al*, 1993), together with synthetic fertilizers, herbicides and pesticides.

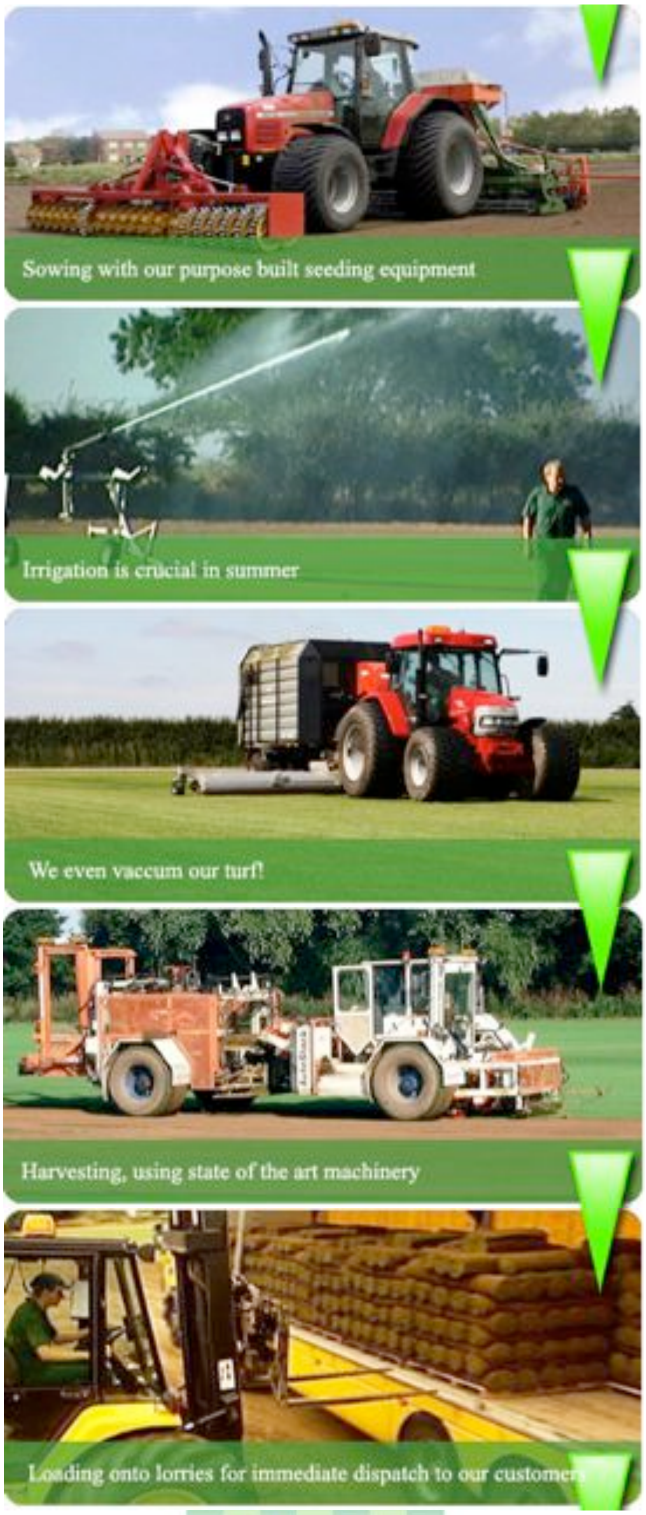
In the United States, the Environmental Protection Agency (EPA) states that I hour of grass cutting is equal to 100 hours of automobile pollution (Werner, 2006). When combined with other engines of 25hp or less, such as leaf blowers and chainsaws, these landscape tools make a contribution to hydrocarbon pollution of about 20% and around 23% to carbon monoxide emissions from mobile sources (EPA, 2006). Illustration 10 shows the turf making process.

Associated devices such as patio heaters, of which 630,000 have been sold in the UK to date, also add to the conflict between leisure and environmental damage by contributing an estimated 229 kg of CO_2, each per year, as shown in table 2 (Boardman, 2006).

Table 2: Estimated Consumption/Emissions per Patio Heater per Year

Average power of patio heater, (S)	8.90 kW
Days per year in use (D)	30 days
Hours per day in use (H)	4 hours
Energy used per year (E = S x D x H)	1,068 kWh
CO_2 emissions per year (= E * 0.214)	229 Kg CO_2

Illustration 10: How Green is your Grass? Energy Used in Turf Production



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Source: http://www.rolawndirect.co.uk/

2.7. Defining Urban Landscape

The problem of relating UA to urban spaces is compounded by the fact that we have a poverty of understanding when it comes to urban space. This thesis does not deny the value of urban space, easily observed by the crammed parks and public open spaces, during lunch times and fair weather days. However, there is no one system for defining and valuing urban open space in the way that we might define other landscapes, such as grassland, marsh or fens. The word 'park', tends to form the ubiquitous noun, together with forecourt, verge or garden (Morphet, 1989). Within Greater London, open-space data is currently held separately by 33 different Borough authorities, with no central database and no common language. Therefore anyone wanting to analyse the total green spaces for London is faced with a long-winded manual task to collect data.

Aside from the quantitative issue, there is a need to understand the types of urban landscapes as products of environmental history, planning and society. Lorzing (1992) came up with the following six qualitative definitions of urban space:

- **Post-war functionalism**: man-oriented using new landforms
- **Landscape approach**: man-oriented using existing landforms
- **Neo-romantic style**: nature-oriented using new landforms
- **Ecological movement**: nature-oriented using existing landforms
- **Post-romantic**: loosely based on ideas from neo-romantic/landscape approach
- **Post-geometric**: loosely based on ideas from classical geometry and functionalism

Understanding how we define and plan urban space will enable an argument for UA to be placed with those definitions. For example, planning for UA could be seen as fitting in with the definition of landscape approach above, in that it should use the existing ecology of the location, together with some influence from the idea of the neo-romantic style. Perhaps a definition of a UA landscape is: man- and nature-oriented using productive landforms. However, despite efforts to understand our urban landscape as a relationship between society, environment and economics, most of our current understanding of urban space is based around the conflict of cost versus value for money, while at the same time borrowing definitions from natural ecology (Gordon and Shirley, 2002).

2.8. Summary

The development of our urban landscape has been characterised by an emphasis on aesthetics and ornamentation at the expense of food growing. While this has lead to the creation of spectacular public and private gardens, it has also severed our link with the ecology of place and food growing as a vital resource. It has also lead to an urban landscape that is dependent on fossil fuel, with a high embodied-energy value, a landscape which surely cannot be sustained given the current government's intention to cut emissions by 60% by the year 2050 (Blair, 2003).

Chapter 3
Urban Landscape As Ecosystem

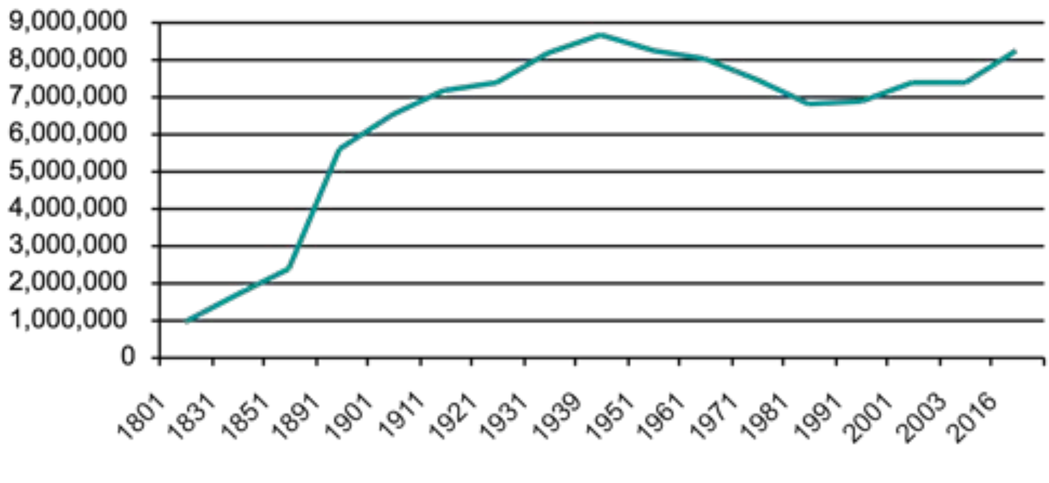
3.0. Introduction

As shown in the preceding chapters, town and country were becoming separate entities, yet characterised by a similar ideology of central planning and industrialisation, causing the landscape to be reshaped for human needs alone (Nicholson-Lord, c1987, p.14). The follow chapter will discuss how this process led to the development of an ecology specific to the urban environment and how this impacts on the food delivery systems and CO_2 emissions.

3.1. Urban Growth

At the start of the 19th century, one-third of all workers were employed in agriculture, however, by the mid 19th century this figure had fallen to a fifth and by the start of the 20th century this had fallen to a tenth (Williams, 1973). Over the same period, London's population exploded from less than a million in 1801 to over 6 million in 1901 and is set to rise to between 7.6 and 8.1 million by 2016[11], as shown in graph 1.

Graph 1: London Population 1801 - 2016

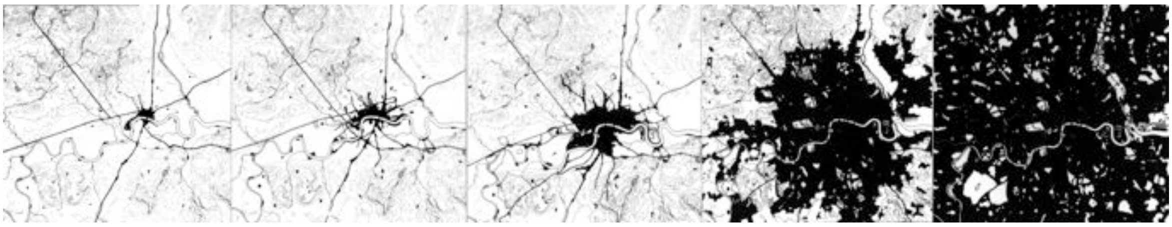


(source http://en.wikipedia.org/wiki/History_of_London)

11: The GLA prediction is 8.1, while the Government set a figure of 7.6 million. Figures from http://www.london.gov.uk/view_press_release.jsp?releaseid=973. accessed 10 march 2006

As Lord Rosebery, a London County Councillor stated in 1891, London had become "a tumour, an elephantiasis sucking into its gorged system half the life blood and the bone of the rural districts" (Nicholson-Lord, c1987). Illustration 11 shows the dramatic growth of London from the 16th to the 19th century.

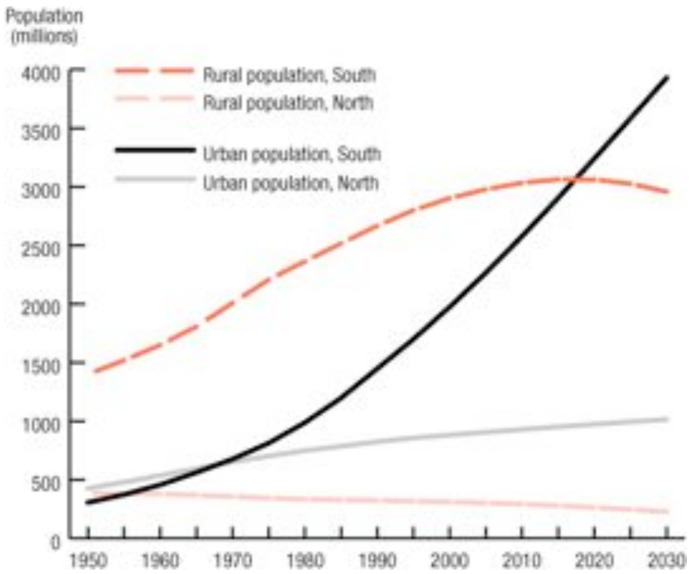
Illustration 11: The Growth of London, 16th Century to 19th Century



Source: Saint, 1999

This is not exclusive to London. By 1950, 30 percent of the world's population lived in urban areas, which had risen to 47% (approximately 2.8 billion) by the year 2000. There is also a split between the over-developed countries of the industrial nations (76% urban) and the under-developed countries (40% urban). It is predicted that 60% of world population will be urban by 2030, and as graph 2 shows, most of this urban growth will be in the developing countries. (United Nations, 2005)

Graph 2: World Population, 1950 - 2030



Source: United Nations, 2004

3.2. Modern Cities and Ecosystems

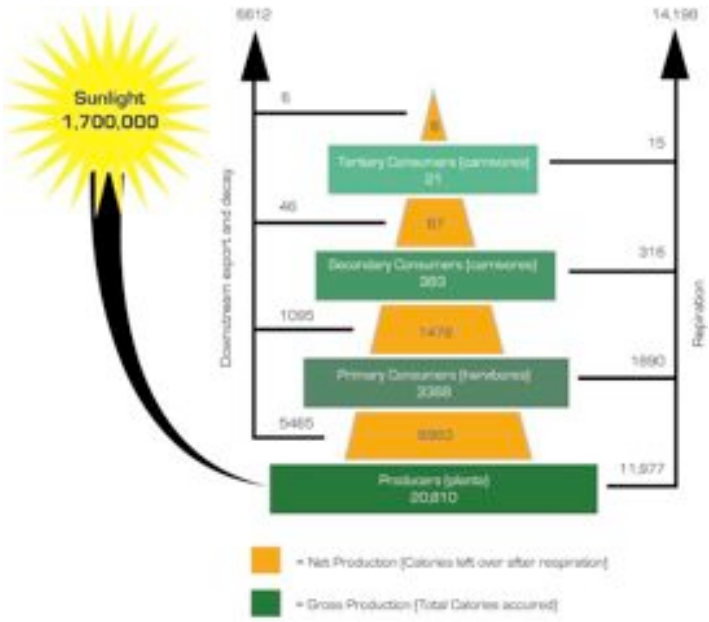
As cities grew, so did their exclusivity as habitats suitable only for humans (Nicholson-Lord, c1987, p.120). By collecting together in ever-dense environments, people were being forced to become parasites on resources well beyond their boundaries and governance (Marras, 1999). These resources represent a formal flow of energy into cities and are usually controlled by utility companies, national governments and food distribution companies. The ability to afford these formal resources is what separates the urban poor from the rest of the population. This is not just a problem for developing countries, as Anna Watson states: "the Labour government has accepted that food poverty is a reality, and that for many people the ability to enjoy a healthy varied diet is constrained by factors out of individual control, such as low income and lack of adequate local food outlets" (Watson, 2002, p.9).

This flow of energy, in the form of resources, into a city, its mass consumption and finally the disposal of its waste, can be thought of as an ecosystem of its own and can be analysed as such (Newman and Kenworthy, 1998). As Jane Jacobs puts it: "to investigate either natural or city ecosystems demands the same kind of thinking" (Jacobs, 1969, p.314). However, it could also be argued that the emerging field of urban ecology (Kaye et al, 2006) should not make direct comparisons between natural ecosystems and urban systems, and that their relationship needs to be better understood. What is clear is that "the energy flow through a city with its factories, automobiles and high power consumption is about 100 times greater than the energy flow through a natural ecosystem" (Odum and Odum, 1981). An organic UA system, with its emphasis on local food production, delivery and consumption, and its treatment of waste as a resource (Jacobs, 1969; Girardet, 2003), would help expand the biodiversity of a region, while also shifting the emphasis towards combining farming and ecology - so helping to form a new field of Agroecology (Lefroy, 1999).

3.3. The Wild Ecosystem

Essentially an ecosystem[12] can be described as an energy or biomass[13] pyramid, with solar energy for plant life entering the system at the base, which passes through different consumer or trophic layers, until it reaches the top or tertiary consumer, as shown in illustration 12 (Southwood and Henderson, 2000, p.509). Matter is constantly recycled through the system by the detritivores (worms, woodlice etc), which then make the dead material available to the original plant layer. An ecosystem's ability to survive will depend on the interdependence of all the consumers through the different layers, beginning with photosynthetic autotrophs (plants) through to carnivores and ending with detritivores (Odum and Odum, 1981). This can be described as a closed-loop food system where the inputs balance the outputs. This type of food-nutrient cycle was also something that humans used before the industrial revolution. After this period, mechanisation and later fossil fuels took over.

Illustration 12: The Natural Ecosystem



Source: after Odum and Odum, 1981

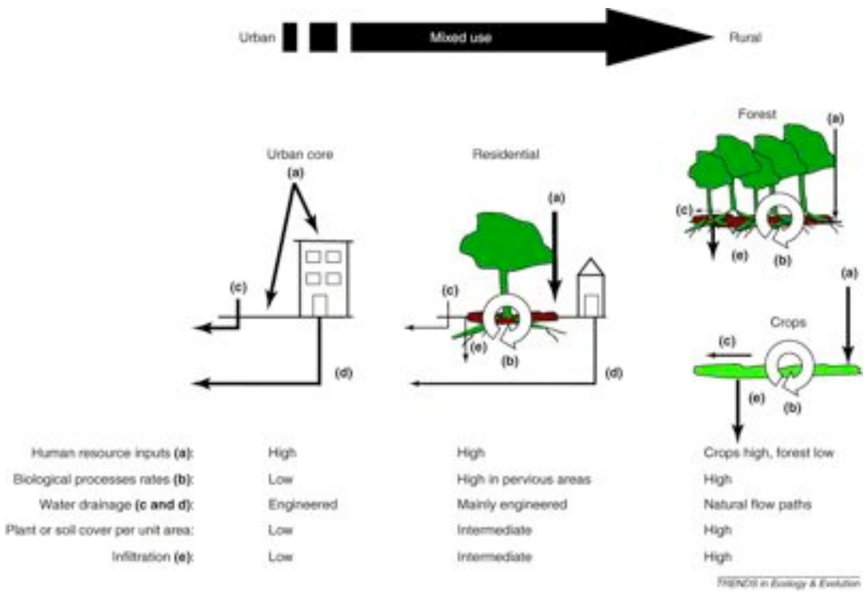
12: The classic model for analysing wild ecosystems was defined by ecologist Raymond Lindeman in 1947.

13: Biomass is defined as, the amount of energy contained within organic matter. This can be measured at any stage of its life cycle (from the living wet weight to the fossilised state). The amount of energy can be expressed in a variety of ways, including calories, joules watts and Kw per square Km per year.

3.4. An Urban Ecosystem

The urban environment, depicted in illustration 13, is driven by an import-dominated culture, which is a significant modification of the natural ecosystem that once stood in its place. While many of the biochemical laws that govern natural ecosystems are consistent with urban ecosystems, it has been argued that human engineering of resources (water, energy, waste), population growth and management of domestic space (culture, attitude and control of immediate landscape such as gardens and waste) have a dramatic effect on the ecology of the urban environment, separate from the wild ecosystem.

Illustration 13: The Urban and Rural Ecosystem

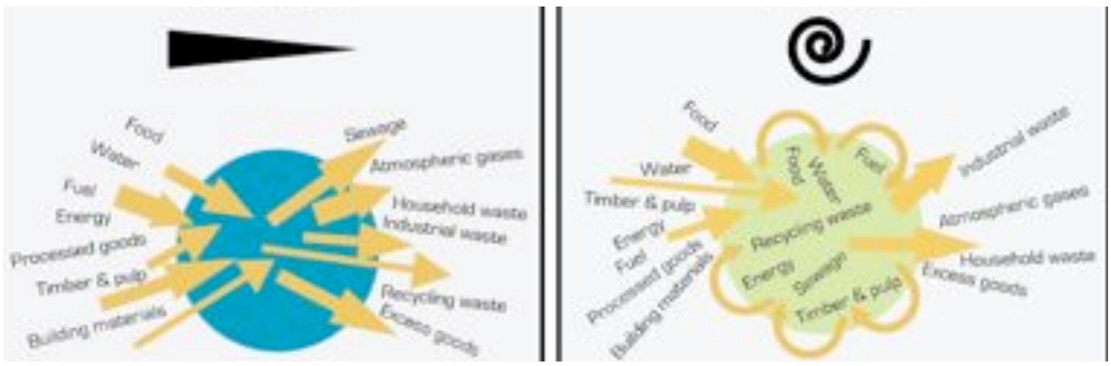


Source: Kaye et al., 2006

One important factor is that the outputs or 'waste' products of the urban environment (containing a great deal of nitrogen phosphorus and other organic matter), are not utilised by the system but are simply ejected by using the two valuable resources as carriers, namely fuel and water (Rees,1997; Arroyo, 2003) Finding a place for UA, is one method for utilising these nutrients within the city environment, while at the same time cutting down on imports. However, this would not be a simple transition and would require infrastructure change and a concerted public educational programme.

In summary, urban energy delivery, of which food represents a large part, can be termed an "open-loop" or linear system (UNDP, 1996, p.178), in comparison to the wild ecosystem that can be described as having a circular metabolism, as shown in illustration 14.

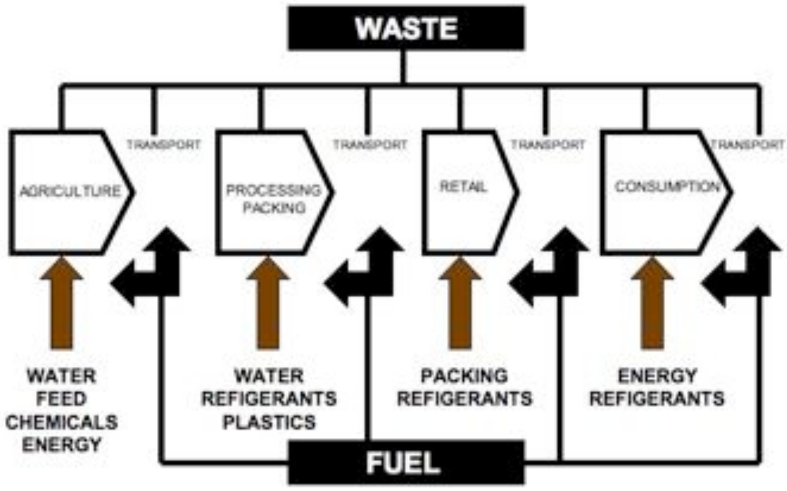
Illustration 14: Linear Metabolism (left) and Circular Metabolism (right)



Source http://www.makingthemodernworld.org.uk/ accessed 03/03/06

One element that differentiates the urban from the wild system is the extra dimension in the form of "food miles", that is, the increasing distances food has to travel before it reaches the urban dweller. Our urban centres have long passed the point when "the size of a city was dictated by how far a farmer and his horse could travel in and out on the same day and the numbers that could be supported within that radius" (Nicholson-Lord, c1987, p.17). In fact, the separation of the farm from the city means that 80-90% of the retail cost of food goes in value added to the raw food by processing, packaging, distribution and marketing, rather than directly to the farmer (Rees, 1997).

Illustration 15: The Urban Ecosystem



3.5. Food, Cities and Climate Change

There are few national governments that would now argue that this linear process is not contributing to widespread and irrevocable climate change[14]. Yet, it wasn't until the 1992 Rio climate change conference that the environmental impact of cities was placed on the agenda (Bulkeley and Betsill, 2003). This is because cities have gradually been separated from the 'rural' or 'natural' and were not seen as having an interconnecting ecology with landscape as a whole.

Since then, a growing body of work has grown up around the need for what is generally termed, 'sustainable cities', including the UN-HABITAT programme (United Nations Human Settlement Programme), the UN Millennium declarations made in 2000 together with the Millennium Development Goals (MDGs). The MDGs place agriculture and urban food-delivery systems high on the list of resources that place a strain on the necessity to achieve sustainability (World Bank, 2004).

However, while the ubiquitous term 'sustainability' still needs definition, what is clear is that modern industrial food-manufacturing systems, together with delivery and consumption, are in crisis and exacerbating the growing rural/urban divide by increasing the migration into cities (Bakker, et al 2000). For example, over the last 50 years, agriculture's share of the UK economy accounted for 5% of GDP and approximately 6% of all employment. However, by the 21st century, these figures had been reduced to 0.7% and 2% respectively (Ball et al, 2006).

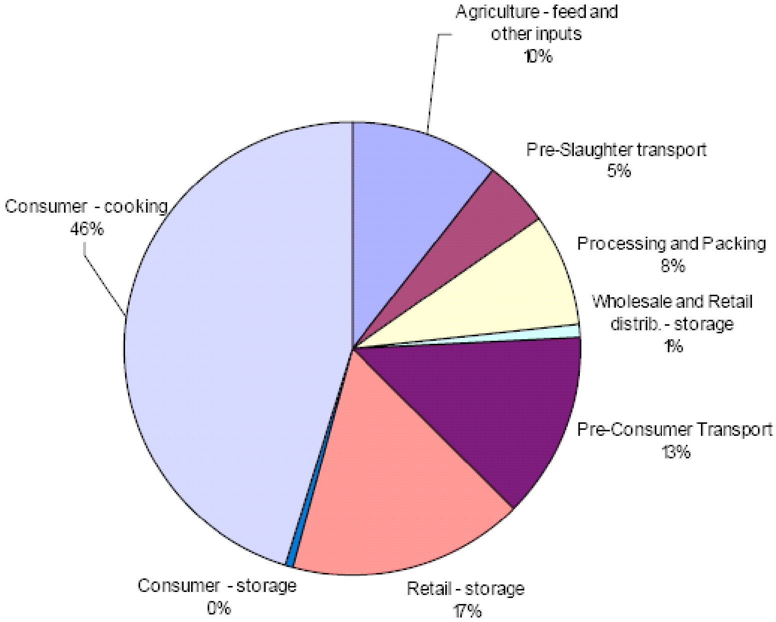
3.6. Formal Food Delivery Systems

The delivery of food to the city is a complex issue, involving assessing energy use, pollution and cost, from primary production, to processing, distribution, retailing and consumer processing (Green, 1978, Pretty, 2005). For example, when measuring

14 Climate change can be defined as " an increase in mean annual surface temperature of the earth's atmosphere due to increases in atmospheric concentrations of greenhouse gases, such as carbon dioxide" Bulkeley and Betsill, n(2003), Cities And Climate Change: Urban Sustainability And Global Environmental Governance, p.1

urban car use, it is difficult to assess which of those journeys are food-related (Watkiss et al, 2005), also emissions from the essential production of fertilisers and pesticides, which account for 1.5% of the CO_2 emitted by the UK, are not included in totals for agriculture, as they are categorised as emissions from industry (Ed. by Viljoen, 2005). Graph 3 attempts to give a breakdown of the energy used at different stages from production to consumption of a whole chicken.

Graph 3: Energy Input for Whole Chicken

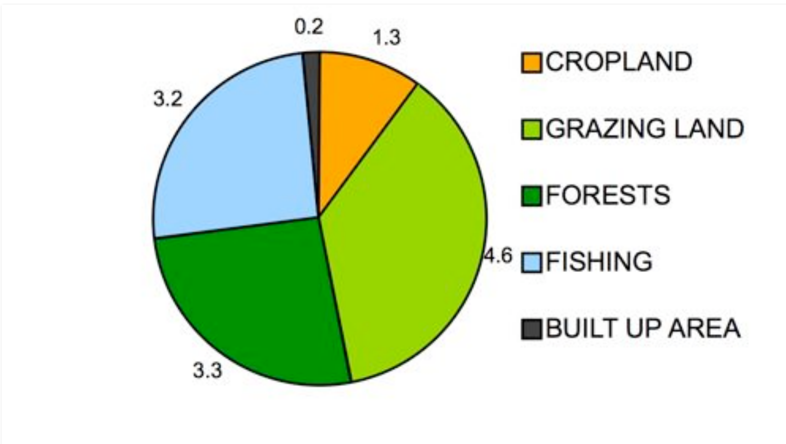


Source: Watkiss et al., 2005

3.7. The Environmental Footprint

One way to understand how cities feed themselves is to look at their environmental footprint. The idea of Ecological Footprinting was developed by Bill Rees and Mathis Wackernagel (1995), and can be considered as a measure of the productive land used by an individual, a nation or even the global community, against the 12.6 billion hectares of productive land available globally, as shown by graph 4.

Graph 4: Total World Biologically Productive Land, 12.6 billion hectares



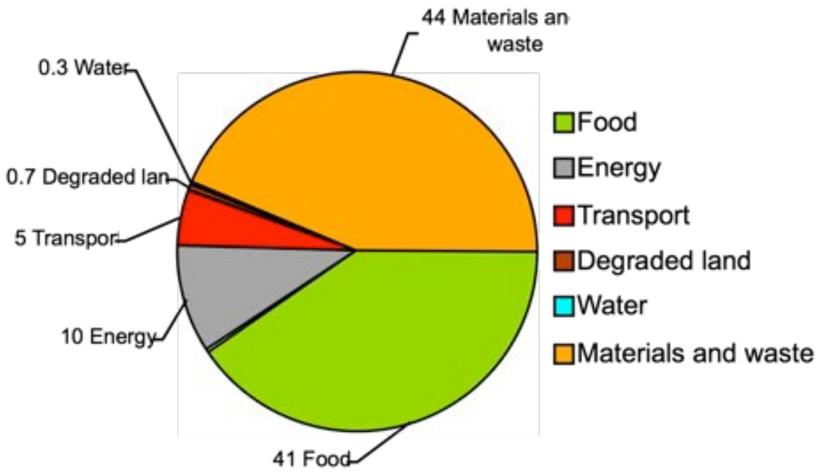
Figures in Billions of Hectares; Source: Desai and Riddlestone 2002

This is then reduced by 10% to allow for wildlife, leaving a figure of 11.3 billion hectares. Against this we can start to calculate how many resources we use and therefore how ‘sustainable’ we are as a society. For example, if we divide the human population of 6 billion, by the 11.3 billion hectares, we get 1.9 hectares per person as an indication of a fare share of the world’s resources (Desai and Riddlestone, 2002, p.25). There is actually the suggestion that we have already exceeded the bio-capacity of the planet in the 1970’s, and are currently consuming 30% more than the planet can sustain (Srinivas, 2005).

3.8. London’s Environmental Footprint

The footprint for London was recently calculated as being 125 times bigger than its surface area (Best Foot Forward, 2002). Moreover, as graph 5 shows, London’s food requirements represent 41% of its entire ecological footprint, second only to materials and waste at 44%. Also, only 19% of London’s daily food requirements are sourced from home-grown products, with the remaining 81% imported daily by air, sea and ultimately by road, travelling an average of 640km (Srinivas, 2005). This compares with only 5% for transport and 10% for energy in use (Camden Council, 2002). Despite these high figures, food as a target for energy-saving policy barely gets a mention compared with turning off lights, congestion charging or insulation.

Graph 5: Ecological Footprint of Londoners



Source: Best Foot Forward, 2002

One issue with the Ecological Footprint system is that results are not currently comparable with other ecological footprint studies because data quality and methods will vary between studies (Best Foot Forward, 2002). However most footprints of UK cities follow the same pattern of results, which is that they exceed their earth share of 2.18 gha and that food constitutes a large proportion of their footprint (Girardet, 2003).

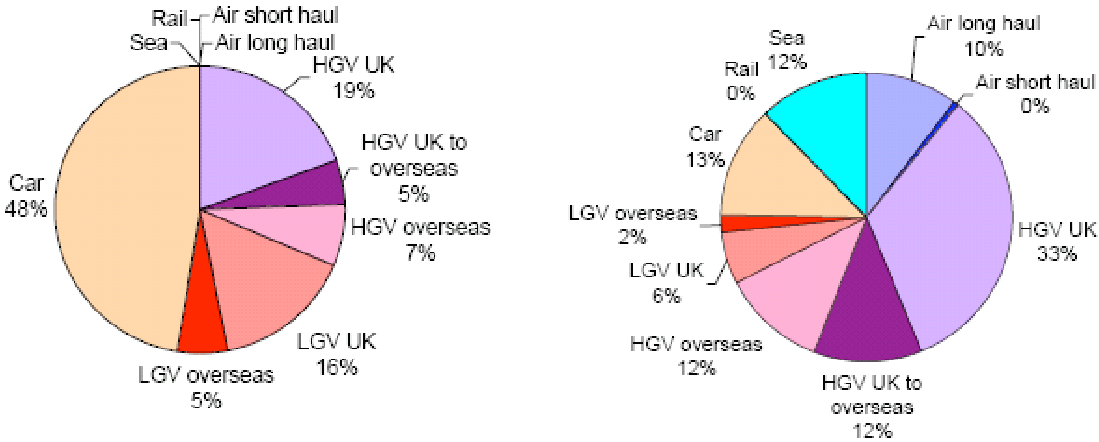
Ecological footprinting can be criticised for giving on an over-simplified picture of the problem and for not allowing enough land resources for biodiversity. However, the recent ecological footprint for London, quoted above, does give a great deal of first-hand data, rather than just summaries and does qualify its methods and their possible shortfalls in some detail.

3.9. Food Transport as a Key Element

Defra identifies four key areas which mark the “dramatic changes in the food production supply chain” over the last 50 years (Watkiss, et al., 2005). Three of the areas are transport related, namely, globalisation of food via the import and export industry, the increasing use of the car because of the growth of out-of-town supermarkets and the trend towards the use by the supermarkets of heavy goods vehicles. All this has caused an large increase in the distances food travel, known as "food miles", up on average by 50% for each trip since 1978 (Watkiss et al., 2005).

One of the major growth areas is in the import export sector where the use of air freight has increased by 140% since 1992 and although it still only accounts for 0.1% of total food miles, it makes an 11% contribution to CO_2 equivalent emissions, as shown by graph 6 (Watkiss et al., 2005).

Graph 6: UK Food Transport Mode Compared With Associated Emissions (2002)



Source: Watkiss et al., 2005.

Left: UK food vehicle-kilometres by transport mode. Right: Associated CO_2 emissions

However, scaling down the food-distribution system and cutting food miles by arguing for local sourcing of food may not in fact reduce pollution. This is because smaller vehicles carry smaller payloads while not offering a similar reduction in emissions. This argument is easily witnessed on most central streets as the ubiquitous "white van man". There is also the debate that flying in out-of-season produce, might have used less energy in its production, relative to energy-intensive non-organic but local farming methods. Defra argue for more research to be done in this area. Other issues are also involved in food miles such as the "food swap", which takes place between the various European countries as part of the Common Agricultural policy (CAP), where similar quantities of foodstuffs are imported and exported in the name of commerce (Dr Lucas, 2001).

While cutting down on food transport is seen as a key component in making cities more sustainable, it is not a suitable indicator on its own because there are too many other contributing factors. However, food miles are an important indicator of the sustainability of a local UA system, where the locally grown food is used as a direct substitute for imported goods.

For example, fresh green beans grown in Brixton, London, as a substitute for fresh imports from Zimbabwe, can immediately register a CO_2 saving because of the removal of the air freighting, provided that this was balanced against the use of fertiliser or pesticides together with local transport of any seeds, soil or produce within London. Therefore, any research that is involved in developing and planning a UA system, such as this thesis, must stress the non-use of fossil fuel transport in its conception, together with organic farming practices[15]. If not, then a much more in depth analysis, along the lines of Energy evaluations must be undertaken.

15: Traditional organic farming practices, together with the mass use of bicycles, were an important component of UA in Cuba after the 1989 collapse of the Soviet Union and the removal of the associated subsidies. While oil-based products such as fertilisers, insecticides and pesticides are still available, they are used in significantly smaller quantities and are used mostly for such crops as garlic, onions and flowers. For in depth discussion, see: AGRICULTURE IN THE CITY A Key to Sustainability in Havana, Cuba María Caridad Cruz Roberto Sánchez Medina.

3.10. Food Miles

Food miles are the distance food travels from where it is grown to where it is purchased or consumed by the end user[16], sometimes expressed as country to country (and assumed as capital to capital), or as farm gate to food table[17]. As stated above, the distances food have to travel, together with the import/export trade are causing a huge increase in road transport, with food, drink and tobacco accounting for a third of the growth in road freight, between 1978 and 1993 (Ed. by Viljoen, 2005)

The type of transport used is also of concern, particularly the air freighting of goods, as this releases around 40 times more CO_2 per ton-kilometre (tkm) than sea transport, see table 3 (Jones, 2002).

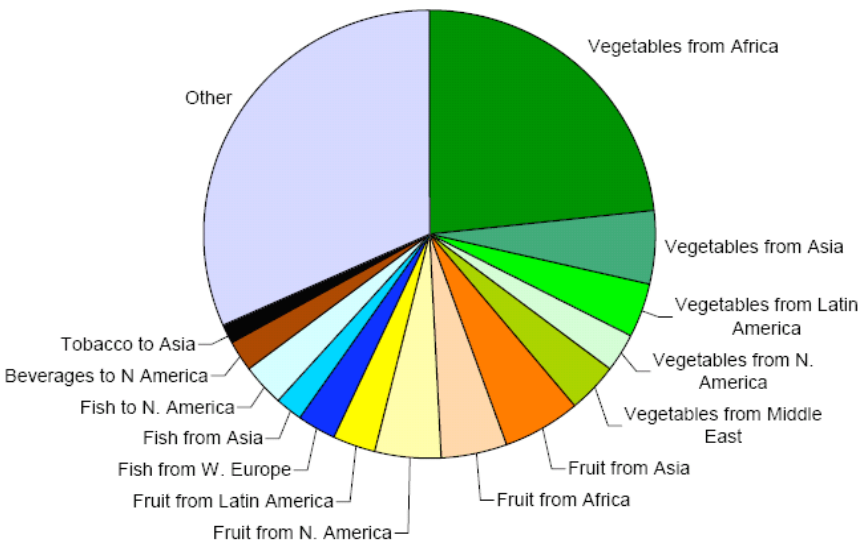
Table 3: Emission Factors For Non-Road Modes (g/tkm)

	rail	deep sea	short sea	air long haul	air short haul
CO_2	30.000	15.335	29.381	570	1580
PM_{10}	7.752	0.006	0.011	0.17	0.57
NO_x	0.305	0.244	0.468	2.98	2.61
VOCs	0.029	0.012	0.022	0.80	2.36
SO_2	0.038	0.259	0.496	0.20	0.18

Source. Watkiss et al, 2005

Also of interest is that imports of fresh vegetable imports account for around 40% of food air freight in or out of the UK, with fruit at 21% and fish accounting for 7%. Grapg 7 shows that the largest category is vegetables from Africa, which is particularly relevant to this thesis, as the method deals only with vegetable production.

Graph 7: Air Imports by Food Type and Source / Destination.



Source. Watkiss et al, 2005

One system for calculating food miles is weighted average source distances or WASD, as shown below (Hayes, 2006). This calculation, while giving a good estimation of the average distances food travels, does not calculate the CO_2

16: Examples of food miles calculator: www.ecohealth101.orh/glossary. Accessed 12/05/06
17: Examples of food miles calculator: www.organiclinker.com/food-miles.cfm Accessed 12/05/06

emissions, as it combines together different transport types into one figure. The formula used for WASD is:

```
WASD =  S (m(k) x d(k))

S m(k)

where:
k = different location points of the production
m = weight (amount) from each point of production, and
d = distance from each point of production to each point of
use (or sale).
```

Moreover, comparing food miles data does not give a consistent picture of the CO_2 emissions from transport, as different authorities give different figures. For example some break down the different gases involved in emissions, which others just state as CO_2[18], while others use grams of CO_2 emitted, per tonne of goods transported (kilometres). There is also no way of tracking the complete route food has taken from the farm to plate including all the different forms of transport, without undertaking a cradle-to-grave analysis. For example, Defra's own report on food miles (Watkiss et al., 2005) only gives estimates of the contributions that non-UK transporting of food makes to the overall emissions, as well as the emissions from the consumer transportation of goods.

Another report, published by Sustain and entitled Eating Oil (Jones, 2002), gives detailed accounts of the energy used in food transport together with the associated CO_2 emission. It also publishes a table of the emissions from a sample of goods brought at a British supermarket (see appendix 3). These figures were cross-referenced with Defra's figures for transport mode and tonne kilometre emissions and are used in chapter 6 to calculate the possible CO_2 emissions saved by growing food locally.

3.11 Summary

Chapter 2 and chapter 3 argue that the slow development of the discourse of both the urban and the rural plan, have been placed on top of the natural ecology, using ideas of aesthetics, efficiency, and economics to dominate, while lacking a coherent vocabulary to engage with the underlying ecology of the landscape; its waterways, climate, wildlife and soil.

The following Chapters 4 and 5, look at UA as a possible example of an alternative to the dichotomies of the planning/architecture, rural/urban discourse by creating the idea of the Agropolis, a merger of the food and city.

18: The greenhouse gases covered by the Kyoto Protocol: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). To aggregate the greenhouse gases covered in the accounts, a weighting based on the relative global warming potential (GWP) of each of the gases is applied, using the effect of CO_2 over a 100 year period as a reference. This gives methane a weight of 21 relative to relative to CO_2 and nitrous oxide a weight of 310 relative to CO_2. SF_6 has a GWP of 23,900 relative to CO_2. The GWP of the other fluorinated compounds varies according to the individual gas.

Chapter 4
UA Landscapes

4.0. Introduction

Chapter 4 will start with a look at the wider subject of UA together with a review of UA-related literature, leading to an understanding of UA practices worldwide. The chapter will conclude with a look at a history of small-scale urban food-growing systems and its relationship to UA.

4.1. UA: Definitions

As an emerging subject area, UA has been defined in different ways, from metropolitan agriculture, street farming (Harper et al., 1976, p.170) to city farming (Levenston, 1994) and the Agropolis (Mougeot, 2005). There are also many gradients, from urban, to peri-urban (a bridge between the city and the rural), rooftop food growing as well as balconies, back gardens, parks, allotments, community gardens, waste ground and foraging for wild urban crops (Mabey, 2001, and Philips, 1988). These can be formally organised, individual, group or informal.
As a starting point, the UN defines UA as:

> "an industry that produces and markets food and fuel, largely in response to the daily demand of consumers within a town, city or metropolis; on land and water dispersed throughout the urban and peri-urban metropolis, applying intensive production methods, using and reusing natural resources and urban waste, to yield a diversity of crops and livestock." (UNDP, 1996, p3)

In this definition of UA, the UN includes the production of non-edible products, fuel material, wood for other uses, feed for animals and pre- and post-production for recycling of waste. Later, in 2000, Mougeot[19] gave a broader definition:

> "Urban agriculture is an industry located within (intra-urban) or on the fringe (peri-urban) of a town, a city or a metropolis, which grows and raises, processes and distributes a diversity of food and non-food products, (re-using largely human and material resources, products and services found in and around that urban area, and in turn supplying human and material

---

19: This definition was used by UNHABITAT's Urban Management Programme (Cabannes and Dubbeling, 2001; Dubbeling and Santandreu, 2003), the Special Programme for Food Security of the UN's Food and Agriculture Organisation (FAO) (Drescher, 2001), and international agricultural research centres such as the Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD) (Moustier and Salam Fall, 2004).

> resources, products and services largely to that urban area". (Koc et al., 1999, p.10)

4.2. UA: Practices

The UN development program has estimated that 800 million people worldwide are engaged in UA. People engaged in UA for some or part of the year varies between, 15 and 70 percent of households in cities surveyed in Africa, Russia, and Eastern Europe;

> "urban agriculture is a significant economic activity, central to the lives of ten of millions of people throughout the world and that it is a rapidly growing industry that is increasingly essential to the economic and nutritional security of urban residents" (UNDP, 1996, p.3).

The United Nations goes on to state that UA practices bring together many of the natural, biochemical activities while also creating links between consumption and waste:

> "few activities contribute so efficiently to improving the urban soil, water, air and living environment while closing the urban open-loop ecological system of resources in, waste out." (UNDP, 1996, p.8)

Yet at the same time they find that UA is very under-exploited by governments, as a method for feeding its populations. In fact, growing food within cities tends to be an occupation that is self-organised outside of administrative and authoritative networks. This type of "bottom-up" self-organisation goes against the history and nature western cities, which has often been tightly controlled and planned using "top-down" hierarchical planning.

Criticism of UA is rarely explicitly stated (Bakker, 2000). However, as we have seen in our discussion of the way UK city planning has developed, there seems little surprise in this. UK planning and architecture has always favoured the aesthetic, the ordered and the hygienic[20], against the chaos of nature which needed to be tamed.

Any opposition stems from the misplaced argument that UA is competing against rural agriculture, or that the land will be more profitably used for building. Public health issues are also high on the list, especially evident by the current bird flu scare as some authorities are expressing concern over the possible spread of diseases from animals to humans (Siemaszko , 2005).

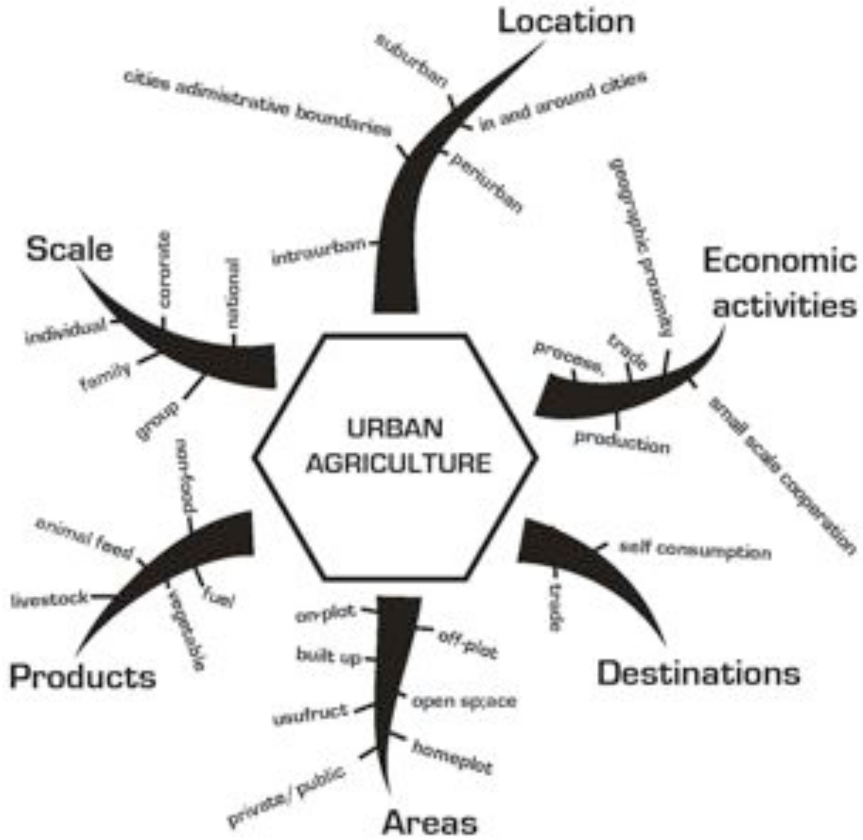
4.3. UA: Distinctions

Location is one of the strongest arguments for UA, in that it brings food production closer to the consumer, by placing its production in, within and around cities or urban areas. UA does not by its very nature eliminate packaging, processing or refrigeration but it does present a good opportunity to reduce these energy-hungry stages. There is also the opportunity to connect the grower with the customer, making a direct link between production and consumption. Illustration 16 presents an overview of the distinctions of UA worldwide (Bakker et al., 2000).

The main subject headings are Location, type of economic activity, scale of production, category of product, area, and the whether it is for self consumption or for trade.

20: See David Nicholson-Lord. The greening of the city. ""regimentation and overelaboration are hallmarks of institutions that have outlived their original function and are losing touch with reality". Page8

Illustration 16: Distinctions of UA



After: Bakker et al., 2000

Area, or land, ownership is an important debate, especially in the UK, as most land already has an established pattern of public, private or institutional ownership. The ability to transcend these rights and use land to produce food is a common discussion. The ability to cultivate livestock, vegetables, flowers, fuel and other non-foodstuffs, does not seem to be particularly inhibited by UA. For example, many authorities in the UK have preferred industrial areas within their UDP and there is no reason why this could not include 'preferred livestock areas'. Moreover, there are already 59 city farms in the UK, which already keep livestock in well-established urban areas. Illustartion 16 provides an overview of UA, together with six defining areas.

4.4. Example of UA Worldwide

UA practices change from country to country, and depend greatly on what economic climate surrounds them. The following sections look at examples of UA in East Africa, China and finally Cuba, to give an understanding of how UA emerges and develops differently across the world[21].

4.4.1 UA in Kenya and Tanzania

East African countries have been going through a rapid period of urbanisation, with approximately 6-8% growth during the last four decades (Mireri, 2006). In Nairobi, Kenya, Home-grown food is critical to sustaining the nutrition of families with 25% of urban families in six of the major cities stating that they would not survive without UA (Mougeot, 1994); in total 64% of the residents of Nairobi grow at least some of their own food (Rees, 1997). What is important to note here is that in neither Kenya nor Tanzania, and in contrast to both China and Cuba, UA does not feature as part of

21: In-depth reports already exist, both online, including International Development Research Centre (IDRC), Canada's Office of Urban Agriculture (www.cityfarmer.org) as well as the Resource Centres on Urban Agriculture and Food Security (www.ruaf.org), which publishes a monthly online magazine.

official government strategies. This is despite a 1988 census that states that UA in Dar es Salaam, Tanzania, provides 20% of the population with an occupation, the second largest provider of employment (Rees, 1997).

4.4.2 UA in China as an Example of Reducing Food Miles

In 1994, UNICEF published a report (Urban Resource Systems, 1984), detailing urban food growing in Shanghai, China, which since 1994 has had no severe food shortages. UNICEF states that most vegetables are grown within 10km of their selling point, appearing at the markets within about 10-15 hours of being picked.

Furthermore, the food-growing communes around Shanghai supply 100% of the fresh vegetables, most grain along with 'significant pork, poultry and other foods' (Urban Resource Systems, 1984, p.23). While the report does not detail the method of agriculture used, together with its use of fertilisers etc, it does show that UA practices cut food miles while delivering fresh produce to the urban customer.

4.4.3 Havana, Cuba: Advanced UA

The UA story for Cuba begins with the collapse of the Soviet bloc at the start of 1989, causing Cuba to lose almost 80 percent of its assured trade and all its access to fuel (Cruz and Medina, 2003). The country then entered a period of crisis called the 'special period', resulting in, amongst other things, food insecurity (Premat, 2005). For example, in 1985 the Daily Calorie Consumption per Capita was 2,929, which had fallen to 1,863 by 1993, causing a marked decline in the health of the population (Cruz and Medina, 2003).

The urban population was particularly hard hit by the food crisis, as the fuel shortage meant that any food that could be produced nationally could not be easily delivered to the city (Cruz and Medina, 2003), a point particularly important given the food miles debate in Chapter 3. The population of Havana responded by growing food within the city, so by-passing the need for food delivery, which in turn prompted the government to form a national UA program, delivering significant resources to the urban food growing population (Bourque and Cañizares, 2000).

UA has developed from these early beginnings into a high-yielding agricultural system, ranging from individual or family gardens on private land to organised groups gardening on public land and institutionally organised gardens (Rosset and Benjamin, 1994, p.70), each with their own level of efficiency.

Table 4: Extent of UA in Havana, Cuba, 1997.

Form of Production	Total Number of Sites	Total Area (ha)
Intensive Gardens	92 gardens	17.00
Organopónicos	96 gardens	23.80
Hydroponics & Zeoponics	3 locations	111.00
Suburban Farms	2,138 private farms	7,718.00
	285 state farms	
Popular Gardens	5,000 gardens	1,854.00
	26,604 gardeners	
Business and Factory Gardens	384 gardens	5,368.00
Household Gardens	Unknown	Unknown
Total	7,998 gardens	15,092

Source: Bourque and Cañizares, 2000

Table 6 shows figures for food vegetable production indicating that yields are as high as 25kg/m2 (250 tonnes a hectare) for Organopónico de Alto Rendimiento (High-Yield Urban Gardens) (Bourque and Cañizares, 2000), to 0.61kg/m2 for the state farms.

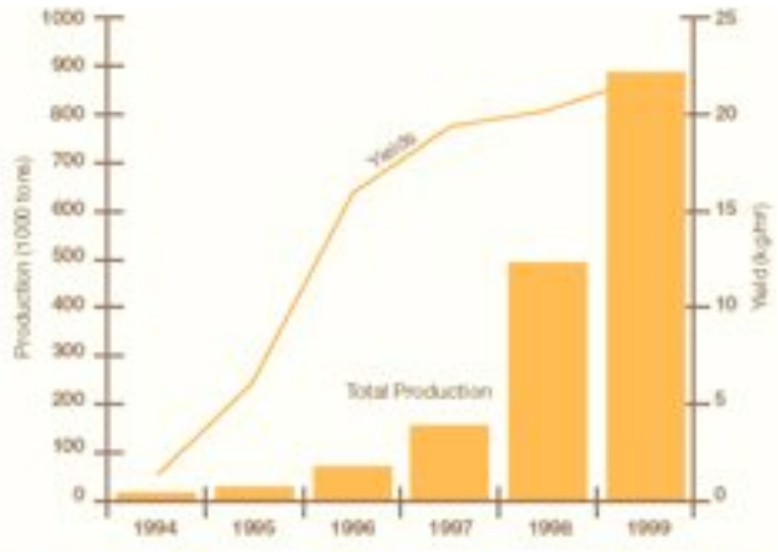
Table 5: Cuba, a Summary of Production Mode, Producers and Average Yields

Production mode	Area covered (ha)	Number of producers involved*	Yields (kg/m2)
State farms for producers' consumption	3,086.00	2,044	6.1
Plots	1,030.14	16,869	81.7
Intensive-cultivation gardens	87.26	663	119.1
Urban community gardens	66.98	672	220.2
High-yield urban gardens	19.1	340	250.0
Field workers	4.489	2,322**	27.0***
Total	8,778.48	22,910	

Source: In Cruz and Medina, 2003
* Asociación Nacional de Agricultores Pequeños (ANAP), Havana (owners and users).
** Converted from kg/ha. *** Converted from qq/cab.

Grapg 8 shows the total production and yields of Organopónico de Alto Rendimiento 1994 to 1999. The graph clearly shows a steady increase over the six-year period, however, it is also clear that production took nearly four years to establish itself.

Graph 8: Total Production and Yields of Organopónico 1994 to 1999



Source: Bourque and Cañizares, 2000

At the start of the special period, there were two fundamental barriers to UA: access to land and the lack of food-growing experience of the urban population (Bourque and Cañizares, 2000) However, in 1993 the government changed land use rights so that any unused land could be taken over by city gardeners and would remain theirs, so as long as it was used for food production. Secondly, the newly formed Ministry for Urban Agriculture coordinated the importing of food-growing knowledge, technologies, seeds and tools. The produce of UA systems was also made available at UA stalls and markets through the city as a way of reducing the black market and lowering prices (Bourque and Cañizares, 2000). Illustration 15 shows a stall selling UA products in a Barrio of Havana, Cuba.

Illustration 17: Urban Agriculture stall, off Maximo Gomez Monte. Havana Cuba. March 2006

Source: The Author, March 2006

4.5. Efficiency of Agricultural Systems Appropriate to the Urban Scale

Gertz, in 1969, states that "any form of agriculture represents an effort to alter a given ecosystem in such a way as to increase the flow of energy to man" (Gertz, 1969). As we can see from the section on Cuba, developing an efficient agricultural system, specific to the scale of UA, that can be retro-fitted into the current urban plan, is essential.

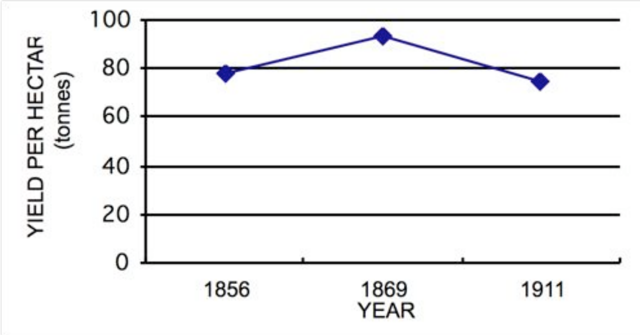
4.6. Example Micro-Agricultural Systems, Suitable for UA

Following on from the discussion of UA in Cuba, is an overview of various types of food growing that have been applied on a small scale that could also be suitable to UA systems in the UK. Complete data is not always available for all systems, but where appropriate, figures that relate to yield, labour, and energy and land use have been included. These figures will be used to gauge possible productivity levels of UA in London. Worldwide, micro UA agriculture has been adopted in a multitude of ways and the subject has been well covered in Urban Agriculture Magazine (van Veenhuizen, No. 10, 2003).

4.6.1 Marais Paris

One of the best examples of metro-agriculture is the 19th-century Marais system of Paris, often called the French intensive method (Stanhill, 1977). Here, about 1400 ha of central Paris, out of a total area of 7800 ha were intensively cultivated using inputs of animal manure and “night soil”. Graph 9 shows that the area continued to produce up to 93.22 tonnes per hectare (1911) and remained in use up until the first part of the 20th century, when it started to decline.

Graph 9: Urban food production. Paris 1844 to 1889



Source: G Stanhill in Agro-Ecosystems in 1977

While the Marais system is may be high yielding, Table 7 shows that overall energy ratio of the Marais system was very low – around 0.25 due to the need to input large amounts of stable manure. However, in contrast to modern agriculture, the energy inputs are all from renewable energy sources and not from fossil fuel in the form of fertilizer and pesticides. Leach concludes that the importance of the Marais farms is that they close the loop on the urban ecosystem by recycling waste locally (both human 'night soil' and horse manure) in sharp contrast to the current view of 'everything to the sewer' (UNDP, 1996) school of waste disposal.

Table 6: Energy Balance for Average 19thC Parisian Marais

Input	Gj ha^{-1} yr^{-1}	Output	Gj ha^{-1} yr^{-1}
Labour	28	Crops	57
Animal Transport	28	Terreau (waste soil)	1800
Stable Manure	6516		
Glass Maintenance	49		
Straw Mats	32		
Miscellaneous	665		
Total	7318		1857

Source: Stanhill, 1977

A further example of small-scale allotment farming was in the former USSR, when it converted 4% of its Kolkhoz[22] farms' land to high-intensity, high-yield (Cole and German, 1970) private allotments, which in turn produced 70% of the total Soviet vegetable production (Crouch and Ward, 1994).

4.6.2. The UK Allotment

The National Society of Allotment and Leisure Gardeners Ltd (NSALG) states that the average size of an allotment is 30 x 100 feet, or 0.0278 hectares. This equates

22: The Kolkhoz farms are collective farms as opposed to Sovkhoz, with are run directly by the state.

to 35.87 allotments in one hectare. Table 7 shows the total Allotments for England and Wales, from figures provided by NSALG (see appendix 6).

Table 7: Allotments England and Wales

England			
Plots	Sites	Total area (acre)	Total area (hectare)
300,000	7800	25,393.00[23]	10275.99
UK			
330,000*	n/a	27,932.30[24]	11 303.80

Source: NSALG (See Appendix 6)

We can start to work out the yields of the allotment system by referring to experiments conducted in the 1970s by the Royal Horticultural Society (RHS) (Personal communication, appendix 2), and Which?Magazine (February 1975, Handyman special insert, p. 21).

According to a document entitled 'Your garden plot – what is its value to you?' (see appendix 2)

> "During 1975 the Royal Horticultural Society maintained a 30 feet by 100 feet vegetable plot at Harlow Carr, with the aim of showing how vegetables for a family of 4 could be provided. The 3 year crop rotation was adopted and most of the work on the plot was carried out by the garden apprentice. Approximately 180 hours work went into the feature."

The first sowings were made on 9th March in the cold frame with the total volume of produce recorded until 22 November of the same year. The report states that at the end of the trial, there were "still plenty of winter crops, leeks, onions cabbage, kale, parsnips, broccoli and brussel sprouts…on the plot."

The total of the produce is 876.1kg for 259 days of the growing season. This would be equal to 31.28 tonnes per hectare. The report, while stating the amount of labour required, does not give an indication of whether fertiliser, pesticides or herbicides were used in the experiment, although the NSALG "believe it was used in a similar manner to normal allotment gardening" [25].

Which? Magazine conducted a similar trial on an allotment of 30 x 90 feet, or 0.025 ha, and found that they could produce 40 tonnes per hectare of vegetables (28 varieties), using 80% fertilizer input (Leach, 1976). This would require approximately 350 hours of work a year, or 17-18% of a 2000 hours a year working time (Leach, 1976), nearly double the time spent on the RHS plot, although it did reach a higher level of production.

23: This is the figure supplied by the National Allotment Society. However, 300000 plots at 3000 sq ft a plot equals 20661.15702 acres. The figure they supplied is used in the thesis.
24: This figure is calculated by dividing the total area given – 25,393 acres by 300,000 plots. This equals 0.084. This number is then multiplied by the number of UK plots (330,000) to arrive at the UK acreage.
25: Email correspondents with Geoff Stokes, National Secretary, NSALG, O'Dell House, Hunters Road, Corby, NN17 5JE. E-mail: geoff@nsalg.org.uk (30/03/06)

4.6.3 War: The Paradigm Shift

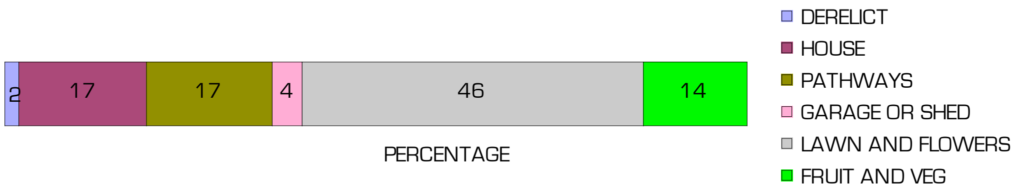
Illustration 18: Before and After, Allotments in Greenwich Park, World War 2

Source: National Maritime Museum, London,1940

Both the First and Second World Wars brought a paradigm shift in the small-scale growth of vegetables, fruit and meat. For example, by 1917, 1,500,000 allotments were producing 2,000,000 tons of vegetables (2,032,093.tonnes) (Crouch and Ward, 1994).

Best and Ward (1956, p.45) made a study of 600 gardens in England and Wales, during 1942, as part of the war effort. They visited 2,921 plots in both urban and rural locations. The results state that the growing of vegetables in gardens (both private and council), was as productive as the best farmland at the time. Moreover, the home-grown food only used 14% of the house plot, as shown by chart 1.

Chart 1: Percentage of Council and Private estates Used for Food Production, 1942



Source: Best and Ward,1956

What is interesting here is that urban development that takes over agricultural land need not lead to a disappearance of food production. One of the conclusions of the Best and Ward report was that, perhaps suburban house development could lead to a sustaining of levels of food production, while integrating them with leisure and housing.

In illustration 19, we can see how a suburban development, is superimposed on previously productive land. Here, agriculture is exchanged for private front and back gardens, yet much of the land remains intact. The issue here is that bad planning fragments land, which can hinder the ability to insert efficient food production into the built landscape beyond private food production for individual families.

Illustration 19 Suburban Development as a Replacement for Farmland

Source: Saint, 1999.

The Best and Ward research was done during the years of the Second World War, when national self-sufficiency, under the banner ‘dig for victory’, was an important factor in providing domestic food provisions. Best and Ward calculated that the combined output of allotments, gardens and nurseries less than one acre, together with casual cultivation, produced 1,125,000 tons an acre, or 455,465 tons per hectare. They also compare the outputs of these food-growing areas with the outputs from agricultural holdings in 1941. The yield for the allotments and gardens was an average of 7.1 tons per acre, against 6.3 tons per acre for agricultural holdings. The total yield for the allotment gardens was also higher, at 1,331,000 tons, against 1,181,000 tons for agricultural land. There are no reliable figures available for current back garden UA, as shown in illustration 20.

Illustration 20: The Urban Food Grower and Urban Leisure Garden, Grosvenor Terrace, London, SE5

Source: The Author, 14/05/06

4.7 Summary

Chapter 4 has argued that UA is a necessary activity for many urban residents, across the globe. It is also a reliable source of food, with a scale of efficiency equal to, if not better than, industrial rural agriculture. The following chapter will look at UA practices in the UK, both past and present.

Chapter 5
UA For The UK

5.0. Introduction
Chapter 5 will look at UA practices in the UK, its relationship to planning and land use, with specific reference to Geographical Information Systems.

5.1 Integrated UA: The Garden City as Example
In Britain, UA has largely been confined to the allotment or back garden, while preferential treatment is given to the traditional public park or private squares and gardens. One of the few examples in the UK of planning for UA with cities was the Garden Cities movement, started in 1889, with the publication of Ebenezer Howard's 'To-morrow, a peaceful path to real reform'. Howard was well aware of the work of anarchist Peter Kropotkin (1985) and described the garden cities as having an 'anarchist basis' (Hall et al., 2003, p.37), creating a new socio-economic system that would rival both Victoria capitalism and bureaucratic centralised socialism (Hall et al., 2003)[26].

Important to the debate around UA is that Howard planned for food production to be embedded within the city plan by surrounding the city with agriculture and allotments. "Every farmer now has a market close to his door. There are 30,000 townspeople to be fed", wrote Howard (Howard, 1898, p24). Moreover, the Garden City would also integrate its sewage and waste streams by returning them to the surrounding land as a valuable source of nutrients, so that it would add to its fertility.

5.2 UK, UA and Planning: a Literature Review
A small amount of research has been carried out on the role played by urban planning on food provision within the UK, most notably is 'Planning for Urban Agriculture in the UK'[27] by Joe Howe and Iain White, published in UA magazine. Howe and White examined 'the role played by planning in regulating urban agriculture on allotments, community gardens and city farms' (Howe and White, 2001, p. 1). They surveyed all the metropolitan authorities in the UK and received a response rate of 47% (32 replies) and found a low level of awareness regarding the relationship of food to the urban environment (47% of respondents). They concluded that UA sat uncomfortably within

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26: The garden cities were designed to be an example of local self government, a vision of 'anarchist co-operation' (26) and a triumph over Top-down planning, which had begun to characterise our town and country planning thus far. We should also remember, that this attempt to bring land ownership to the population, on paper at least, was being proposed at a time well before the eventual granting of universal suffrage, which did not appear until 1928.
27: This paper also appeared under the name of 'Awareness and Action in the UK'

the UK planning framework, which generally plays a small role in promoting food production.

Other research in the UK was carried out as early as 1996, in the West Midlands Metropolitan Borough of Sandwell, where initiatives were taken to explore community agricultural initiatives as part of the 'practical, legislative and economic feasibility of community agriculture' (Davis et al., 1999). The paper questions not our ability to use urban and peri-urban space to produce food due to problems such as poor soil, bad climate or lack of knowledge, but because of the 'ghosts that oppress us' (Davis et al., 1999).

These ghosts it defines as the institutions that we have inherited from the past, 'the forces and relationships of production that have shaped … landscapes and society' (Davis et al., 1999, p.52). As explained earlier, the ghosts that walk our park landscapes are those of Repton, Brown and finally Loudon, who laid the plan for our present parks and gardens, and the institutionalisation of Architecture and Planning.

5.3. Guinness Trust

One example of spontaneous UA is the Guinness Trust estate at Loughborough Park, in South London. The estate comprises 399 residences spread across ten five-storey blocks. Three years ago, a small group of residents approached the Trust with a view to turning some of the grassed areas into allotments, as shown in illustration 21

Illustration 21: Guinness Trust Estate UA - March to June, 2005

Source: The Author, 2005

One of the reasons why the trust is so ambivalent about the UA practice is that they are currently seeking planning permission to demolish the estate and rebuild it, to house 500 residents (ECD Architects, 2006). The extra density would be achieved by removing the green spaces that currently surround the estate. The proposal is currently at the planning stage and is facing opposition form residents and the Lambeth Council (Planning Applications Committee, 2006).

Illustration 22: George, One of Three UA Gardeners at the Guinness Trust.

Source: The Author, May 2005

5.4. Land: the Base Energy Source of UA

While a great deal of the literature surrounding UA argues clearly for the positive effects of growing food in cities, whether this is expressed as recycling organic waste, feeding people or reduction of food miles, there is however, a shortage of research on *methods of assessing the quantity of urban space* that could be used for producing food.

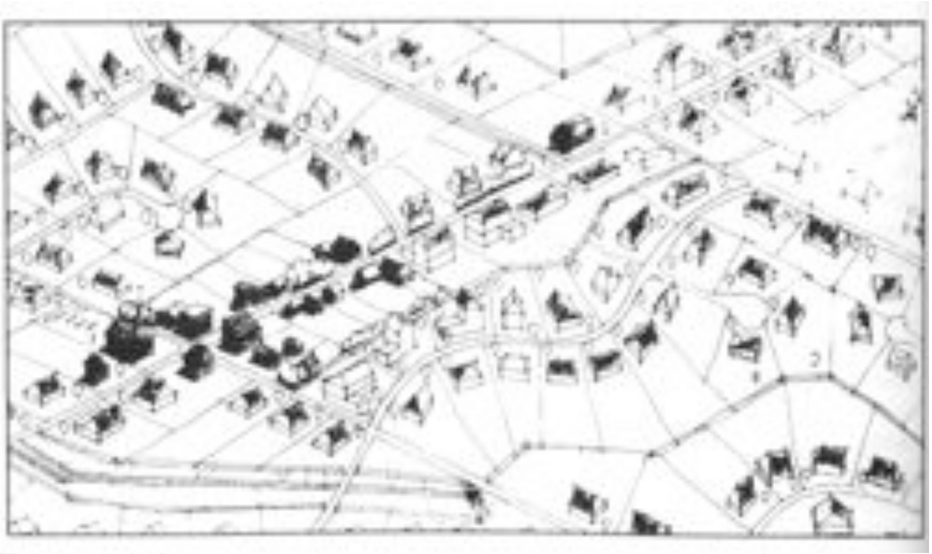
Also, having defined land as a resource, it needs to be placed in context with the surrounding architecture, its inhabitants and food miles. This is essential if food is to be treated as a vital energy source, alongside oil, electricity or gas. The development of UA practices requires an accurate method of data collection about land availability and expected yields together with energy input/output data and an understanding of social organisation.

However, any method of “defining, counting, formalising and ordering UA spaces” (Premat, 2005) must be able to include local users on their own terms, while simultaneously engaging with the discourse of planning and architecture. Unless this feedback loop between design and occupancy is established, any UA practices will simply become tools of reformism within the already established hierarchy of professional practices.

5.5. Planning for Green Space

Illustration 23 compares a suburban plan of subdivided and private spaces with a mixed-use development of the same density that includes a market garden, plant nurseries and corner stores (Ed. by Viljoen, 2005, Nicholson-Lord, c1987). Here, the same green space is consolidated into a community green area; which could create a more efficient micro-agriculture environment.

Illustration 23: Planning for Density and Food



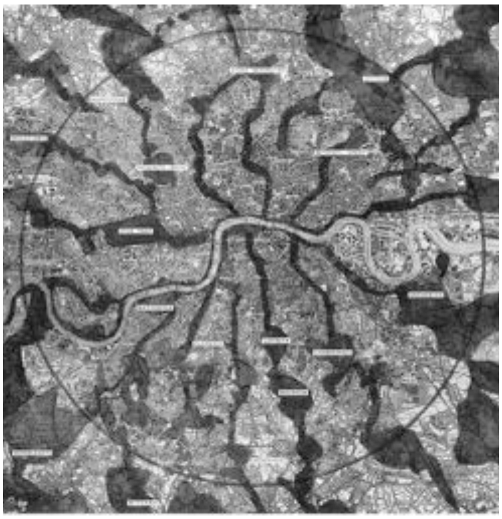
Top: Suburban development with traditional subdivision of green space. Bottom: Mixed use development of same density but with small scale market gardens. Source: Hough, 1995

The idea of planning continuous green space through London has a particular history dating back to 1840, as shown by illustration 24. Loudon, who arguably invented the public park, conceived of a London full of breathing corridors (Loudon, 1829), while Ralph Tubbs (Tubbs, 1942) in the post-war era came up with a similar plan that attempted to connect together a network of green corridors.

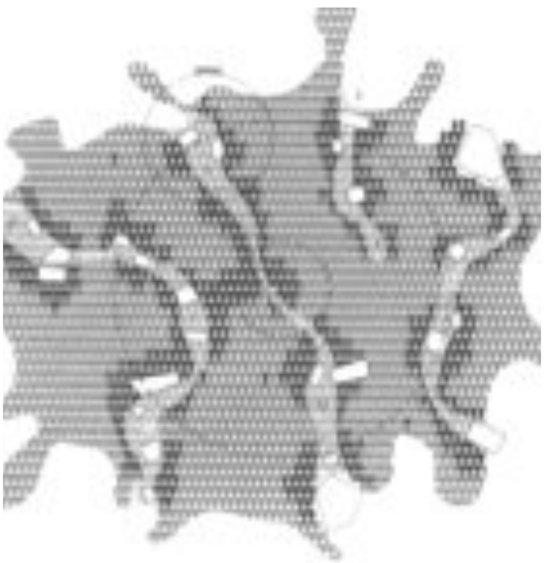
This idea was developed still further in 2005 as the continually productive urban landscape or CPULs. The idea behind CPULs is to create continuous corridors of productive green space. This would perhaps be the next step in UA planning, where food provision is integrated into home-zones and car-free streets, blurring the gap between private and public space. However care should be taken not to continue the practice of imposing master plans on to the urban landscape, as has been the norm in the post war years, but to seek an understanding of the local site and tailor UA accordingly.

Illustration 24: Three Examples of Continuous Green Urban Landscapes

Loudon's 1829 idea for 'breathing corridors' in London, published in the Gardeners Magazine of the same year. The plan would create continuous green areas across London. Given Loudon's obsession with the ornamental, it is unlikely that these would have been conceived as productive corridors.



Ralph Tubbs, in 1942 published 'Living in cities', including this plan to create continuous parks and green space through London.



Continuously productive urban landscape brings the idea to maturity with continuous spaces full of urban agriculture.

5.6. UA Assessment Methods

One of the best known and oft-quoted works on UA for London is 'City Harvest' (Garnett, 1999). The report has calculations for land area by type, with a calculation of the percentage that could be used for food growing, as shown in table 9. However, the report states that it is "probably impossible to calculate accurately" (Garnett, 1999, p.118) the productive capacity of London.

Table 8: UA in London with an Expected Yield of 10.7 tonnes per ha.

Area Type	Area ha	Potential UA as %	UA Area ha	Yield
Farmland	13,566	50	6,783	72,578
Other Green Belt	40,034	20	8,007	85,673
Allotments	831	100	831	8,892
City Farms	51	25	13	136
Community Gardens	20	25	5	54
Public Open Space	14,617	5	731	7,820
Derelict Ground	1,388	1	14	149
Gardens	38,014	14	5,322	56,945
Totals	108,521	20	21,705	232,246

Source: Garnett, 1999

Its method is to estimate the land available from a variety of sources, including NSALG and a report by the London Ecology Unit in 1992 (see appendix 5). This report used a selection of high resolution black and white aerial photographs, to estimate the amount of ground cover for a variety of habitats in Greater London. The report is widely quoted[28] and translates its results into percentages rather than hectares and then averages out the figures across London (Dawson and Worrell, 1992). It should be noted that this work was done before the introduction of computerised mapping systems.

Surprisingly little work has been done in this area of UA, which has been identified by A.W. Drescher (2000) as an important step towards making UA workable. A clear understanding of spatial distribution of land types, within a language that formal institutions can recognise and use, is necessary in order to convince planners and governing bodies of the need to include UA in policy decisions (Drescher, 2000).

5.7. Geographical Information Systems

One language that planners do understand is 'Geographical Information Systems' (GIS), a digital tool that processes and links spatial data into location-specific information (Demers 2005)[29]. This information system uses the familiar style of a

28: Despite the fact that this work is widely quoted, there are no versions of the report stored with the British Library. A copy of the report was eventually tracked by contacting one of the authors who still works at the GLA.

29: This information is displayed in the form of a map, an abstraction of the real spatial phenomena and therefore not miniature version of reality. If it were, then we would end up as a character in the Jorge Luis Borges novel, 'On Exactitude in Science' (29). The novel describes a country where "cartographers evolved a map of the empire that was of the same scale as the empire and that coincided with it point for point". This idea was developed from an earlier Lewis Carroll novel "Sylvie and Bruno" (29). Here the printed map as its starting point, but is also able to combine quantitative data (area measurements or distances) with qualitative data (interviews or photographs) (Montoya, 2003) and output information in the form of user-defined graphs or tables.

One of the benefits of the GIS system is its ability to move away from the familiar printed or cadastral[30] approach to mapping, which uses pre-classified data along with fixed and finite symbols, to a flexible dynamic approach, defined by the user interactions (Demers 2005). Illustration 25, by Christopher Saxton was one of the first attempts at the later when he mapped the whole of England and Wales in 1579.

The idea of moving away from the fixed map is extremely relevant to for UA practices, as the practice is looking for new definitions of spatial information told through custom narratives of the city.

Illustration 25: Christopher Saxton, A Cadastral Map England and Wales, 1579, to Show Ownership.

Source: An Atlas of the Counties of England and Wales, Saxton, 1579

Many of the latter qualitative data collection inputs are familiar to those used in Post-Occupancy Evaluation (POE), a discipline developed to study buildings after they have been occupied for some time, in an effort to form circular links between designers, owners and the users of the dwellings (Preiser et al.,1988). Once mapping data has been input to GIS systems, it is easy to measure all areas of green space available, together with an evaluation of comparable yields from similar, adjacent land. These explicit calculations are something which UA literature has, until now, only been estimating (Garnett, 1999).

Within the available literature, it seems that GIS has only been applied in a few UA situations, sometimes regarding existing UA activities (Dongus and Drescher, 2006,) and others, which combine aerial photography with GIS to identify possible UA opportunities (Castro, 2003, Houston, 2001). The Public Participation GIS (PPGIS) WebRing argues for GIS to be combined with community mapping, and participatory planning, to give a more holistic view of the landscape (Corbett, 2006).

Combining GIS in such a way will help offset the accusation that it is a top-down tool used for the creation of master maps (Premat, 2005), which often exclude people from the decision-making process (UNDP, 1996, p.178). Important here is the work done by Levenston et al., (2001), using GIS systems, shown in illustration 25, although the paper, published on the web, gives no indication of the method used beyond naming GIS as a tool.

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character used maps that are scaled one mile to one mile, although they go on to point out that “we now use the country itself as its own map and I assure you it does nearly as well”.

30: Traditionally, the Cadastre involves mapping land so that ownership and management can be determined. The first examples of this are the maps of Christopher Saxton, who in 1579 was the first to map England and Wales.

Illustration 26: GIS and a Canadian suburb

Source: Levenston et al., 2001

5.8. Summary

Chapter 5 has argued that UA needs to develop as a concept, so that planners, local government and urban dwellers can start to conceive of it as part of a much-needed urban vocabulary.

While the simple act of growing food in your back garden is a useful, productive and relaxing occupation; it needs to be brought into the wider debate about our parasitic urban life, climate change and wider issues such as the work/non-work equation. UA needs to move from a private, invisible activity to a more tangible movement, that makes demands on the use of urban space alongside, recreation, leisure and the legacy of urban horticulture. Chapter 6 will look at a method for measuring a potential UA system in central London.

Chapter 6
Primary Data Collection

6.0. Introduction

The following section describes a methodology, together with its research design and application for assessing the potential for retro-fitting UA into urban grassed spaces. The work deals only with grassed space, together with derelict ground but not with roof tops or the vertical allotment space of buildings. This is because on the whole, grass or ground level space is available for immediate occupation, requires little or no infrastructure change, is socially inclusive and provides a 'shop window' for UA practices.

The primary outcome of the work will be to calculate the amount of space available for UA within a specific area[31], together with the potential yields in terms of tonnes of vegetables per hectare over a 259-day growing period[32]. This outcome will be related to the density of the area, along with CO_2 emissions from food miles and current grounds-maintenance practices.

6.1. Measuring Input/Output Data

The measurements outlined in the preceding chapters, will be applied to the research method. These are:

- Chapter 2: emissions from lawn maintenance equipment
- Chapter 3: emissions from food miles
- Chapter 4: yields from UK allotment tests
- Chapter 5: using GIS systems to measure urban land types

6.2. Methodology and Research Design

The methodology involves combining existing GIS data[33], detailed OS maps (or equivalent) together with satellite images, and site visits, to gain an understanding of how the neighbourhood functions, both as a plan and on a day-to-day basis. While interviews or questionnaires should form part of this process, so that the local user can be fully involved, they were discounted as part of the research design. This is due to the difficulty in explaining the subject of UA to an audience who have been underexposed to the subject. However, with environmental awareness growing, questionnaires should be developed to form dynamic links between local residents and

31: The scale of the UA area under investigation is limited only by the amount of time available for the research project, mainly because site visits, and the inputting of data are very time-intensive activities.
32: 259 days relates to the growing session of 9 March to 22 November used by the RHS in 4.5.4
33: Supplied by statutory authorities such as Local councils, or the Greater London authority

statutory local authorities. This can be seen in illustration 27, where the output of the results are fed back into the original GIS stream as well as to local users or community groups.

Illustration 27: Overview of Methodology

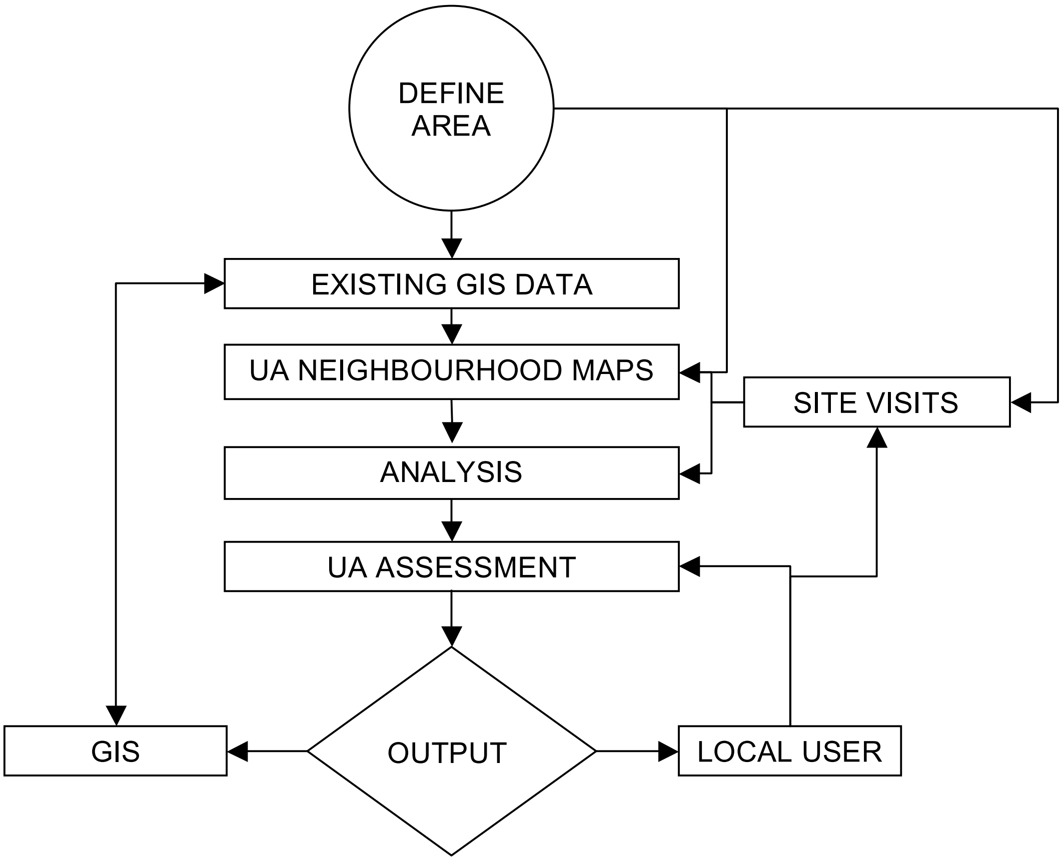
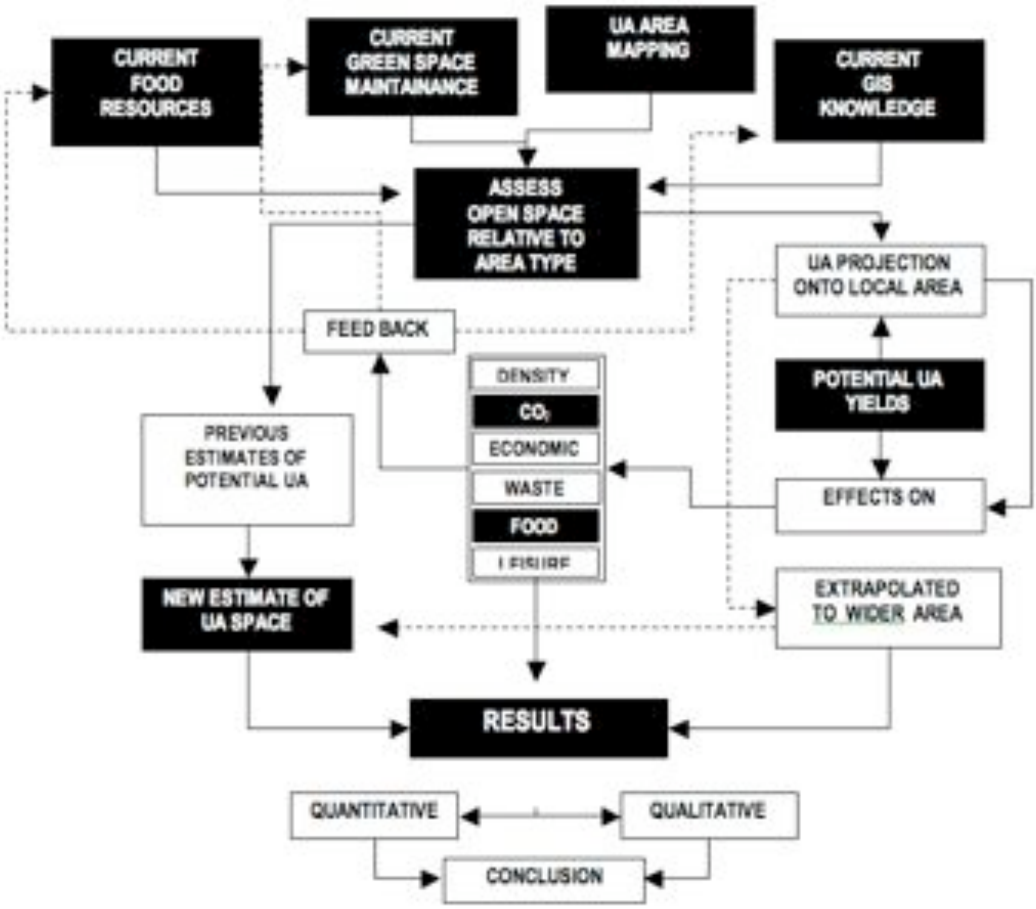


Illustration 28 details the research design, with indications for primary (black boxes) as well as secondary research objectives (white boxes). The primary research is related directly to the amount of space available for UA, its potential yields and the relationship of this output to food miles and CO_2. The secondary research, which examines potential implications for the primary work in the areas of waste management, cost, leisure and urban planning, would be developed as part of further work.

Illustration 28: Research Design



Key: Black boxes denote primary data collection. White boxes are secondary data collection.

6.3. Method – The Elephant and Castle, London.

From March to April 2006, an area within south central London was chosen for assessment using the above methodology. The area measures 1,913,352.51m^2 (191.34 ha), or 0.12% of the 157,208 ha area of Greater London[34], and is centred on the Elephant and Castle, London.

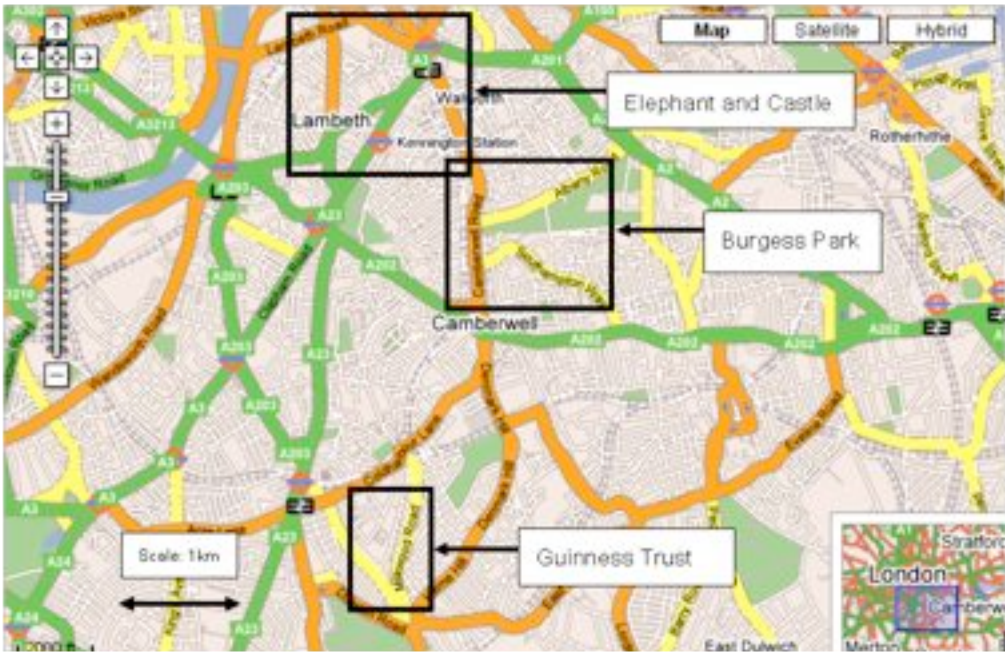
34: The chosen site sits mostly within the Borough of Southwark, one of the poorest in the UK, with a density of 84.9 persons per hectare (average London density is 68.9). Heavily redeveloped in the post-war era, the Site is currently part of a new regeneration scheme, which seeks to increase its density by 270%, predicting that it can do this without any increase in its current carbon emissions (http://www.elephantandcastle.org.uk/) site has also been declared an 'Energy Action Area' (EAA), by the Mayor's office (http://www.london.gov.uk/mayor/environment/energy/), and will showcase renewable technologies, such as bio fuel and wind turbines. It should be noted that the EAA scheme, makes no mention of what the implications of feeding such an increased population would have on CO_2 emissions for the area.

Illustration 29: The Elephant and Castle Roundabout

Source: http://www.johndavies.uk.com/lon-ele.htm. Copyright John Davis 2001

Illustration 30 shows the main Elephant and Castle site in relationship to two other test sites, firstly around Burgess Park (107.36ha) and secondly the Guinness Trust Estate (23.11ha) off Loughborough Rd, SW9. The two other test sites were chosen so that some elements of the results could be compared, contrasted and extrapolated over a wider area. However, these extra sites were not visited, and data was collected only from satellite images and GIS measurements.

Illustration 30: The Three UA Areas Outlined on a Map of South London.

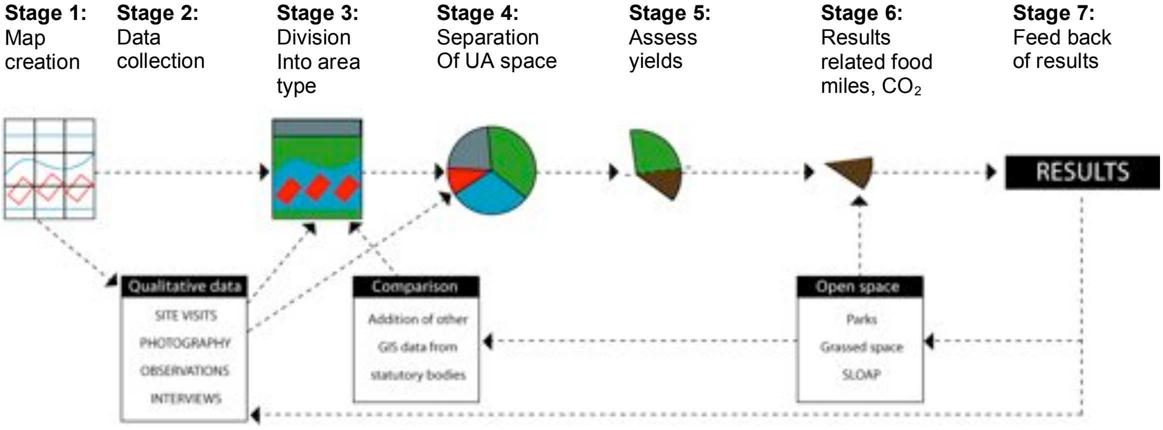


Key: The three UA test areas (not to scale), in relationship to the surrounding environs of south London.

Illustration 31 shows the method undertaken, broken down into seven stages, which are:

Stage 1 Digital map creation
Stage 2 Qualitative (site visits/photography/interviews) and quantitative (GIS data/satellite/area types) data collection
Stage 3 Division of infrastructure using qualitative and quantitative data
Stage 4 Separation into food-growing and non-food-growing areas
Stage 5 Assessment of yields
Stage 6 Comparison with current food imports, CO_2 and grounds maintenance
Stage 7 Results, analysis and feedback

Illustration 31: The seven stages of UA mapping method



6.3.1 Stage 1 Digital Map Creation

Software used:

- Esri Arcmap. Version 9.1. (www.esri.com),
- Adobe Photoshop version CS, for editing jpegs
- Adobe illustrator CS used for creating and exporting vectors into dxf file format.[35]
- Google Earth satellite image software, free online (www.earth.google.com)

For the purposes of this research, OS data was downloaded (http://edina.ac.uk/digimap/), in the form of individual jpeg (raster) squares, together with its longitude and latitude geo-references. These geo-references are required by the ArcMap software to position the newly created 'UA maps' in relationship to any existing GIS data. The downloaded OS maps were then compared with satellite images of the corresponding subject area, as shown in illustration 32. The author used Google Earth's satellite images software, which is available online and is of high enough quality to view considerable detail.

Illustration 32: Satellite Image Juxtaposed with OS Raster Map

Source: Left - www.earth.google.com Right - Ordinance Survey Map of the Same Area

35: The vector software could be substituted with another programme, as long as the software can accept jpeg images and can output into dxf files for ArcMap.

The Elephant and Castle test area was analysed and broken down into seven categories of open space, all of which had the potential to support UA. These were:

- Private space (back and front gardens)
- Public open space (combined parks and open areas around housing estates, etc)
- Dog exercise areas
- Derelict land
- Private squares
- City Farm and community gardens
- Allotments

Some main roads and landmark structures were also added to the GIS map to give it a sense of place within the local environs.

6.3.2 Stage 2: Qualitative and Quantitative Data Collection

Parallel to this, as shown in illustration 33, site visits were then undertaken from March 22 - April 12, 2006) and the area was documented using photography and note books. These were then compared with the relevant satellite images and OS maps, so that features such as walls, height of surrounding superstructure and existing use could be understood. The time spent on site was also of benefit, because the use of space often changes through the day and during different weather conditions. For example, grassed areas can often be empty, even during good weather, but are often invaded by children, just after school closing time.

Illustration 33: OS Data Combined with Photography from Site Visits, Manor Place, SE17

The above illustration shows a series of photographs with have been linked to an OS map of Manor place, SE17. Each photograph clearly shows aspects of the site, including surrounding walls (image 2), present usage (no ball games – image 5), or the division of continuous space between the park and the housing estate (image 6).

6.3.3 Stage 3 Division of Infrastructure Using Qualitative and Quantitative Data

Illustration 34 shows the seven types of open spaces listed above in 6.5.1, marked out onto the OS map (shown underneath at 50% transparency) using the Adobe Illustrator software.

Illustration 34: Example of Combining Raster Maps with Colour-Coded Vectors

	Public grassed areas		Private Square
	Private gardens		Main Roads and Buildings
	Allotments		

Source: Screen shot, Adobe Illustrator.

6.3.4 Stage 4 Separation Food Growing Areas

Once the seven categories of space had been defined, units representing UA could be inserted onto the landscape. The UA units were only inserted into the green public areas, or areas where site visits could be made. The size of the UA units are relative to the standard allotment, which equals 0.0278 ha. From this original unit two other units were drawn; the first equalled a half of the original allotment (0.0139), the second a quarter (0.00695) of the original[36]

Using the standard allotment gave a sense of scale to the planning of UA, which enabled custom UA shapes to be inserted if the standard allotment templates would not match. Once someone has grasped the scale of the single allotment, it becomes much easier for them to get a sense of dimensions and place.

For the rest of the areas, a percentage was set aside using previous research of the use of open space for food production, as shown in table 10. Information such as access to the area, its proximity to major roads, or current usage became essential information when considering inserting UA into the landscape. Areas that are closer than 7.5m to major roads were discounted because of the possibility of pollution from road traffic. (Wade, 1986).

36: At the start, a check was made as to the accuracy of the vector drawing programme relative to the translating process into ArcMap. They turned out to have an accuracy of 98.6%.

Table 9: Potential Land Set Aside the UA as Percentage

Area type	% of area used for UA
Allotments	100
Dog exercise	14
Private sq	14
Derelict	100
School	14
City Farms	25
Private garden	14
Public green space	Calculated from visual mapping of area and site visits

The use of 14% for UA listed in table 10, is derived from the work of Best and Ward (1956) and also used by Garnett in City Harvest (1999). The use of percentages is partly because aerial photography was not of high enough quality to give an accurate account of the present UA activities with private space. Illustration 35 shows the red coloured UA units against the green of the public grassed areas and the purple of the private gardens (The Imperial War Museum is marked in black, top left, with the Elephant and Castle shopping centre, also marked in black, upper centre).

Illustration 35: UA Plots Inserted into Elephant and Castle (close up of large area)

	Potential urban agriculture		Private Square
	Private gardens		Public grassed areas
	Allotments		Main Roads and Buildings

Once the vector drawing stage had been completed and exported using the 'dxf' file format and imported into ArcMap, they were geographically referenced, using the longitude and latitude information collected when the original jpegs maps were downloaded. The ArcMap software, as shown in illustration 36, was used to measure the various different urban land types identified in the test area, together with data relating to their size in square metres. These custom maps were overlaid with GIS data from the Greater London Authority (GLA) and Southwark council, who were responsible for a large part of the area.
This following data was included:

- Census information relative to wards for Greater London (population)
- District borough boundaries (area)
- Southwark parks data (area)
- Sites of Interest for Nature Conservation - local (SINC) (area)
- SINC Borough 1 and 2 (area)
- Metro open land dated 28/06/05 (area)
- Green belt region (area)
- Food access maps (collected from site visits)

Illustration 36: Elephant and Castle Test Area and Environs

	SINC data		Census wards
	UA research area		Thames River
	Southwark parks data		

Screen Shot from ArcMap, GIS Software Showing SINC, Census and Southwark Park Data.

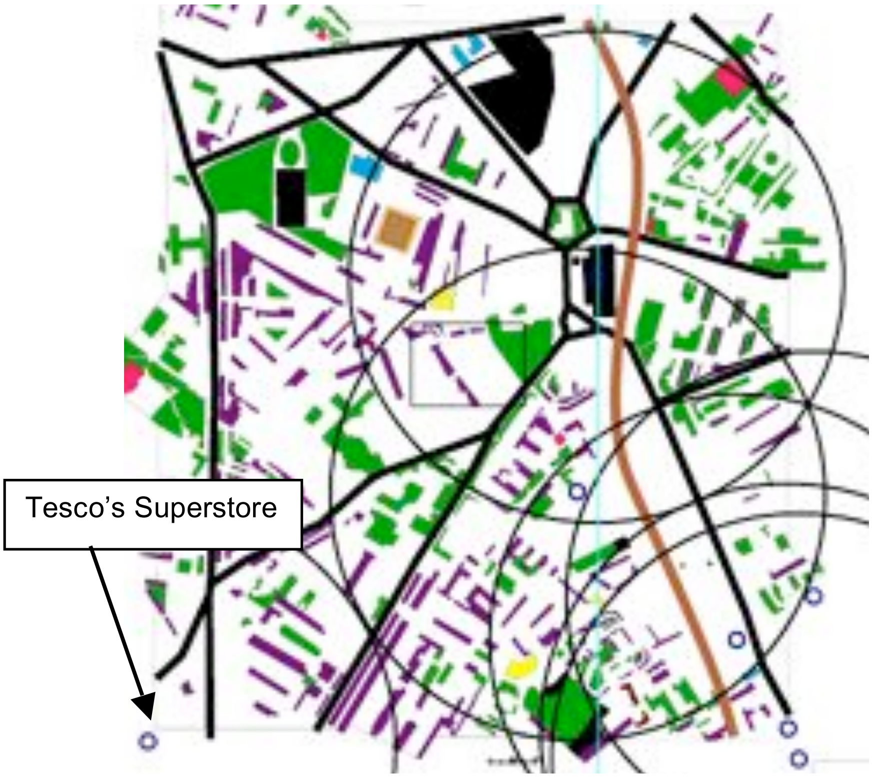
6.3.5 Stage 5 Assessing Yields and Food Miles

The basic unit of productivity was taken as the 100 x 30ft raised bed allotment, with an expected yield of 31.28 tonnes of vegetables per hectare[37]. This figure was taken from the test data derived from the NSALG described in Chapter 4.

37: The work only considered vegetable production, as this was considered more efficient use of the space than animal rearing, where a food source would need to be provided for the animal before the animal could be eaten. Also, most of the data available regarding yields, related only to vegetable production and not animals such as chickens, rabbits or pigs.

A survey was made of all the shops within the area, to determine what access there was to food and where the food came from. This information was entered into the GIS system as a 'food access' map, illustration 37. The information was then used to calculate which UA areas fell within a 500 metre distance of the food shops. 500 metres is considered the distance someone is prepared to walk from their front door and back to purchase food (Viljoen et al, 2005). If a UA area falls within this 500 metres and we can calculate the quantity of UA produce that will be made available, then we should be able to calculate how much UA produce can be used as a direct substitute for imported food[38].

Illustration 37: Food Access Maps



Map shows 500 metre radius from shops selling fresh fruit

Illustration 37 shows the various food stores together with a 500m circle drawn around them. The Tesco's superstore, in the bottom left hand corner, was the only store that sold all the vegetables grown in the NSALG allotment experiment (date of purchase, April 28th 2006).

The country of origin, clearly displayed next to the vegetables, was noted for each product. Where a product could be sourced from either the UK, or imported from abroad, the imported version was chosen[39]. This would give a total CO_2 for the potential produce grown in the allotment space if it was imported rather than grown locally.

Table 10 shows mode of transport, as well as the emissions caused by importing various food products, as published in Eating Oil (Jones, 2002).

38: For the final calculation regarding food miles, the assumption was made that the food bought at the Tesco's superstore would be bought by all residents in the Elephant and Castle test site.

39: Using food labelling, which refers to 'country of origin' for fresh unprocessed vegetables was considered accurate for use in this thesis. The same cannot be said of processed foods, where multiple ingredients can be sources from one country, processed in a second and packaged in a third.

Table 10: Produce, Food Miles and CO_2 Emissions

Country	Mode	CO^2 emissions in grams of CO_2 per kg
Spain	Lorry	96.67
Italy	Lorry	107.50
Netherlands	Boat	20.00
Zimbabwe	Plane	3,755.00
Kenya	Plane	2,327.00
New Zealand	Boat	230.00
Netherlands	Boat	16.67
USA	Plane	6,002.00

Note: These figures were obtained from Jones, 2002. They are not inclusive of energy used in farming, processing, packing or consumer transport. (See Appendix 3)

These figures do not take into account the transport from the farm to the processing plant, store or consumer's homes. Referring back to the discussion in Chapter 3, we can see that food transport only constitutes a percentage of the energy used in delivering food to the city. As discussed above, this thesis is not a life cycle analysis (LCA) or Emergy analysis, therefore a full calculation of all inputs and outputs will not be made. The food miles itself works as an indicator, in degrees of magnitude relative to the re-localisation of food production.

As such, no allowance was made for possible car use within the UA model, as the calculations for transport were considered already on the generous side. Also, there is an assumption that the local nature of the plots and the difficulty in parking due to controlled parking zones in London will limit car use. This is not the case with the Tesco's superstore, which has ample free parking facilities, therefore a figure of 220 grams per km (Jones, 2002) was added to food miles calculations, assuming a 3km weekly drive to the superstore.

These results were then related to average vegetable consumption in the UK per person per week, see table 11, which is 1596g (Pretty, et al., 2005) and multiplied by the population of the area, as stated in the GIS census data supplied by the GLA, to calculate the relationship between yields and density.

Table 11: Average Vegetable Consumption UK

WEIGHT	VEGETABLE TYPE
797.00g	Potatoes
273.00g	fresh green vegetables
526.00g	other green vegetables
1,596.00g	Average total food consumed per week

Source: Pretty et al., 2005

6.3.6 Stage 6 Results, Analysis and Conclusion

The results can be split into four main subject areas:

- The total area available for UA plots within the test area (hectares)
- Yields for vegetables from the UA plots (tonnes per hectare)
- Yields related to surrounding density (kg of vegetables per person)
- CO_2 from food miles and grounds maintenance equipment

The results for the Elephant and Castle test area will be compared to the results from the Burgess Park and Guinness Trust areas, to see if there are any inconsistencies, correlations or to see if perhaps there is a bench mark so that the results might be extrapolated for the whole of Greater London.

6.4. Summary

The results of the research will now be present, together with an analysis of its implications.

Chapter 7
Results And Analysis

7.0. Introduction

This chapter will deal with the results of the UA assessment method performed in Chapter 6. These results will then be analysed relative to the various discussions outlined in the chapters which preceded it.
These areas are:

- Chapter 2: UA in relation to urban green space
- Chapter 3: UA as part of the urban food delivery system
- Chapter 4: UA as a successful metro-agricultural system
- Chapter 5: GIS as a tool for assessing UA potential
-

Conclusions, limitations and further work will also be touched on but will be discussed in greater length in chapters 8 and 9.

7.1. Area, Results and Analysis

The total area of the three test plots measured 321.81 ha, which represents 0.2% of the 157,208 ha[40] area of Greater London and 1% of the 31,930 ha of inner London[41]. While this represents a small area of London, it would, however, be safe to assume that the results could be extrapolated out into the surrounding area as a great deal of it has a similar superstructure.

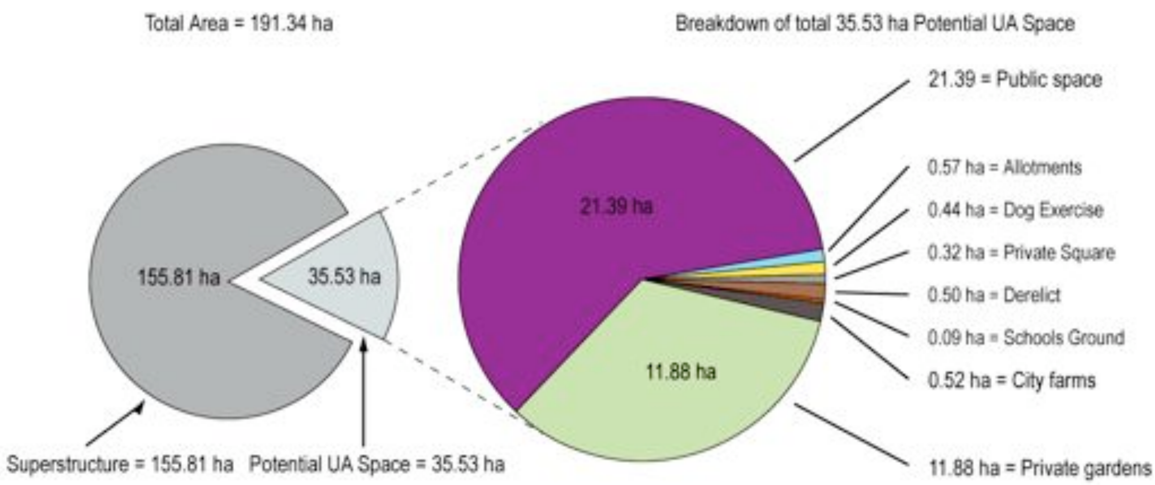
Therefore, by extrapolating within the immediate environs, the potential UA test area, together with estimated results, could rise to approximately 6% of the area of Greater London. However, it should be remembered that the purpose of this thesis was not to *estimate* the potential for UA in London, as had been the case in other related literature, but to develop a *specific and accurate* assessment method. Furthermore, only the Elephant and Castle was analysed using the complete method; the Burgess Park and Guinness trust sites will be referred to as comparisons, but the results will concentrate more fully on the former.

Graph 10 shows that within the total Elephant and Castle area of 191.34ha, a total of 35.53 hectares (18.40%) were recorded as being either green open space, derelict brown field, schools, city farms, private squares, private gardens or allotments. The largest two areas were private gardens at 11.88ha and public green space at 21.39ha. The private gardens therefore represent 6.2% of the total 191.34 ha under investigation, which is substantially lower than the 19.3% recorded by the often-quoted

40: http://www.esrc.ac.uk/ESRCInfoCentre/facts/index9
41: Calculated from the GIS census data supplied by the GLA

work carried out by the London Ecology Unit (Dawson and Worrell, 1992). However, this figure would most certainly change to a higher figure if the research had been carried out just a few kilometres south, as the architecture changes from 20th century to 19th century and garden sizes increase.

Graph 10: Breakdown of UA as a Component of Total Area.



One important part of the process is the feeding back of the new GIS data into the statutory bodies that supplied some of the original data. This is important because there was found to be a large discrepancy between both the Southwark green space data and the GLA green space data[42].

One of the surprise results is the similarity of the allotment allocation (0.57ha), compared with dog exercise areas (0.44ha). While it would be counter productive to argue against dog exercise areas as an important part of the parks system, it does highlight the low priority given to food growing in a city compared with leisure activities. Also, because dog-exercise areas are usually sited within parks, it would seem logically to argue that if space can be afforded to 'dog toilets', then why not compost toilets and allotments? Illustration 38 shows an exclusion zone within a park, similar to those that could be used for UA. Another issue is that London currently spends 15% of its food footprint importing pet food, second only to meat at 28% (Best Foot Forward, 2002).

Illustration 38: Dog free areas, Shepard's Bush, London

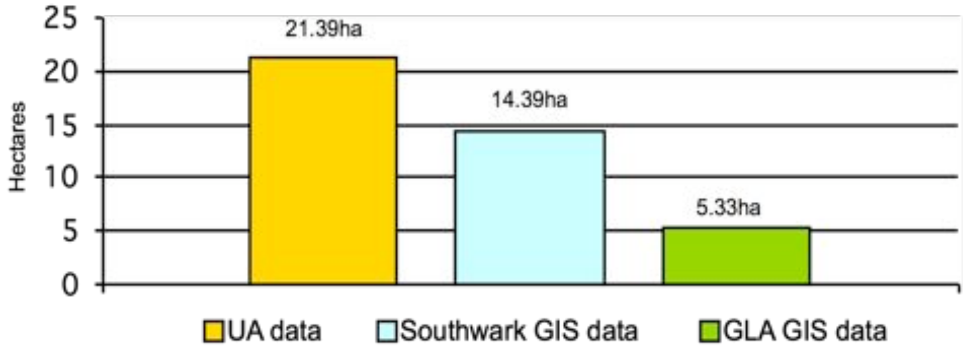
Source: The Author, July, 2006

42: This is partly due to the fact that they have different criteria for wanting to plot green space but also because there is no agreed standard for cataloguing urban green landscapes.

The GIS system also allowed for a comparison between the green-space data held by Southwark, the GLA and the data recorded by the UA method. Chart 2 looks at public green space only and shows that within the 191.34ha UA test site at Elephant, the UA method recorded 21.39ha of open space, while Southwark recorded 14.39ha and the GLA, 5.53. However, it should be noted that while this could be viewed as a failing on the parts of the respective bodies, it was perhaps outside their remit when they assembled the GIS data bases. Furthermore, they were under no obligation to disclose all the data they held, and while their cooperation was significant, they may still have our databases, which may come to light when the data is fed back to both Southwark and GLA, as part of the circular process.

Furthermore, this result highlights one of the key statements of this thesis, which is the need to see food as an energy source and the regard of urban land as the raw fuel for such a system. If there is no clear measure of green urban space, then it will be impossible to calculate its potential yield. Therefore, if the method had relied solely on the GIS data supplied by either Southwark or the GLA, then the result would have been approximately 60% to 25% lower.

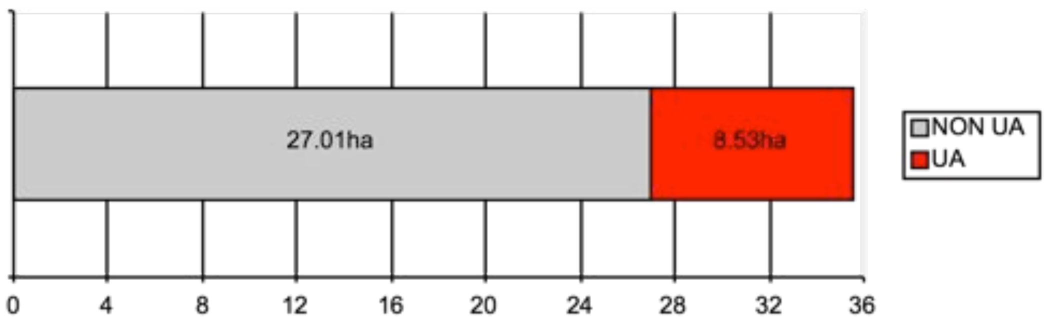
Chart 2: GIS Data for Green Spaces and the Elephant Test Site.



7.2. The Potential UA Component

Chart 3 shows that out of the 35.53ha of open space identified, 8.53ha could be converted to UA, while still allowing for current recreation and leisure activities. This represents 24% of the potential area (35.53ha) and 4.5% of the total area (191.34ha).

Chart 3:Breakdown of Potential UA Space from 35.53 ha Total.



All Units in Hectares

A full breakdown of how the areas that could support UA were calculated, together with its potential yields are covered in table 12. Except for the public areas, whose yields were calculated directly from the GIS software, the rest are calculated from percentages. This was necessary for example, in the case of private gardens as site visits were impossible and often the satellite data did not present enough details on their own.

While, this was a disappointment, there was still the result of knowing the exact amount of space covered by private gardens (11.88 ha) within the given area and the allocation of 14% to UA, is in line with previous research (Best and Ward,1956, Garnett, 1999). There are also two City farms[43] within the area and both were included as public open space in the data collection. After site visits, it was decided that a figure of 25% for UA should be attributed to them. This is because they already have a strong UA presence; for example, both have small apiaries and sell honey to the passing public[44].

7.3. Potential Yields

Table 12:Yields as a Product of Area

Area Type	Total (ha)	UA as % of Total1	UA area (ha)	Potential Yield per (ha)[2]	Total Yield for UA (tonnes)
Public Space	21.39	26.75%	5.72	31.28 tonnes	178.99
Private Gardens	11.88	14%	1.66	31.28 tonnes	52.05
Allotment	0.39	100%	0.39	31.28 tonnes	12.20
Dog Exercise	0.44	14%	0.06	31.28 tonnes	1.93
Private Sq	0.32	14%	0.05	31.28 tonnes	1.40
Derelict	0.50	100%	0.50	31.28 tonnes	15.64
School	0.09	14%	0.01	31.28 tonnes	0.40
City Farms	0.52	25%	0.13	31.28 tonnes	4.07
TOTAL ha	35.53		8.53		266.63

7.4. Yields Relative to Density

The yield of 266.63 tonnes for the 8.53ha UA area can be expressed relative to the average annual vegetable consumption of 1,348.21 tonnes, for the 16,245 residents of the test area. Table 13 shows that over the 259 days of the growing season, 16.245 people require 956.67 tonnes of vegetables.

Table 13: Average Vegetable Consumption

Population of Area (established from GIS Census Data)	16,245.00 persons
A: Total, vegetable consumed for 16, 245 persons per year (tonnes)	1,348.21
B: Total, average veg consumed over 259 days growing season (tonnes)	956.67
C: Potential UA yield (tonnes)	266.63
UA yield as a percent of total vegetable consumption (C as a % of B)	27.87%

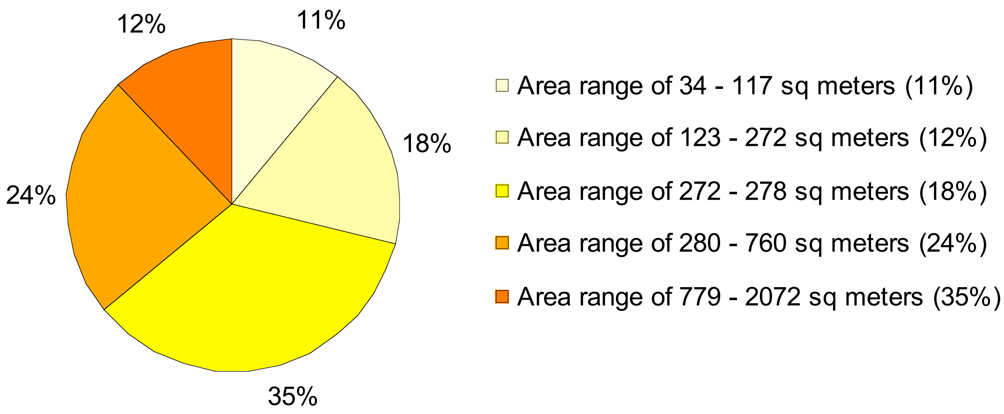
43: Roots and Shoots and Walworth Farm Garden
44: The author collected data from the Walworth Farm Garden, over the 2004- 05 season, and calculated that the two hives produced approximately 91kg of honey. No figures were available for Roots and Shoots.

Therefore the UA yields for vegetables of 266.63 tonnes, when expressed as a percentage of 956.67 tonnes of vegetables is 27.87%. However, this figure is only relates to the 8.53ha of the total 35.53ha grassed area, potentially available for UA.

7.5. Planning for Urban Green Space

While the figures for yields per hectare do suggest that UA systems would be successful related to the local density, it is unlikely that a constant yield of 31.28 per ha would be achieved, due to the fragmentation of green space, as shown in chart 4. For example, 29% of the total 5.72ha of public green space was smaller than the standard allotment size of 272 m^2, with over 11% of it being under half that size again.

Chart 4: Public UA Area (5.72ha), Banded by Size.



Notes: the middle range area of 272 – 278 sq meters is equivalent to the UK allotment size.

However, research in Cuba has suggested that there is not a direct relationship of size versus yield (Cruz and Medina, 2003) but it is the interplay of labour versus yield that determines efficiency.

The figure can also be expressed as a square meter relative to the density. For example, if 27% is taken as the bench-mark for the contribution UA could make to the average vegetable requirement over 259 days, then each person would require 0.5m^2 to fulfil this. This would give architects and planners a valuable tool within the design process, along side other environmental measures, such as renewables, insulation, or passive solar gain. Furthermore, while this figure relates to the retro fitting of UA into grassed space, the potential yields are just as applicable to rooftops, balconies or roofed courtyards, as well as new builds.

7.6. Yields Relative to Food Miles and CO_2

Table 14 shows the results of calculating food miles, by listing the RHS vegetables in column one and then sourcing the same vegetable at a local supermarket, identifying its country of origin (column two), together with the supposed mode of transport (column three). The CO_2 emitted per kg of product, in column four, is calculated from table Jones 2002 (see appendix 3). Column four and five are then multiplied together to give a total CO_2 for each imported vegetable.

Table 14: Food miles, yields and CO_2

Column A	Column B	Column C	Column D	Column E	Column F
Produce Grown on RHS Allotment	Total Weight of Produce (kg) Grown on RHS Allotment	Country of Origin of Vegetables in Tesco store (April 2006)	Supposed Transport Mode for Tesco's	Total grams CO_2 Emitted per Kg of Produce for Transport	Total grams CO_2 for Transport of Produce
Carrots	66.22	Spain	Lorry	96.67	6,401.27
Parsnips	10.43	Spain	Lorry	96.67	1,008.23
Beetroot	70.76	Italy	Lorry	107.50	7,606.70
Lettuce	135	Spain	Lorry	96.67	13,050.00
Radish	21	Spain	Lorry	96.67	2,030.00
Broad Beans	35.38	Netherlands	Boat	20.00	707.60
Peas	16.78	Zimbabwe	Long haul	3,755.00	63,008.90
Cabbage	106.14	Spain	Long haul	96.67	10,260.20
Brussel Sprouts	12.25	Netherlands	Boat	20.00	245.00
Turnips	20.87	Italy	Lorry haul	107.50	2,243.53
Runner Beans	52.62	Kenya	Long haul	3878.33	204,077.72
Dwarf Beans	16.33	Kenya	Long haul	3878.33	63,333.13
Marrows	12.7	Spain	Lorry	96.67	1,227.67
Courgettes	24.04	Netherlands	Boat	20.00	480.80
Onions	25.85	New Zealand	Boat	230.00	5,945.50
Spring Onions	22.5	Netherlands	Boat	20.00	450.00
Potatoes	94.35	Italy	Lorry	107.50	10,142.63
Leeks	15.42	Netherlands	Boat	20.00	308.40
Celery	27.7	Netherlands	Boat	20.00	554.00
Spinach	4.99	Netherlands	Boat	20.00	99.80
Spinach Beet	65.77	Netherlands	Boat	20.00	1,315.40
Sweet corn	19	USA	Long haul	6,002.00	114,038.00
Totals	867.1				508,534.70
Private car		3 km weekly	220 g/km		24,353.10
TOTAL					532,887.80

Column B multiplied by Column E equals CO_2 Totals

Source: Jones, 2002 and RHS, Appendix 2

An allowance of 220 g/ CO_2 (Jones, 2002) for a weekly car trip to the supermarket was then added to the total grams of CO_2 emissions for the food miles of 508.534.70 grams. This car use was calculated as a 3km weekly trip[45] as a factor of 259 day food growing season (24,353.10g/ CO_2) and gave a total of 532,887.80 grams of CO_2 for the 0.028ha plot.

It should be stated that these figures represent a worst-case scenario, as there was the potential to purchase 8 out of 22 of the vegetables listed from a UK source. While this would have given a smaller figure for the food miles, it does not address the major problem in the food miles calculations, which is the (increasing), use of long haul aircraft to bring fresh vegetables into London, which contribute the majority of the emissions. This was discussed in detail in Chapter 3.

45: The car usage is a difficult figure to calculate as there are no accurate checks made of what percentage of car use is strictly for food transport. DEFRA, in its food miles report (Watkiss et al, 2005), states that the average UK shopping trip is 4.82km and 60%, or 2.89 of these trips were made by car; this figure has been rounded up to 3km for use in these calculation. However, it should be noted, that DEFRA's calculation are only estimated.

Table 15 shows these CO_2 figures relative to one hectare and to the Elephant and Castle UA area of 8.53ha, giving a total of 162.24 tonnes CO_2. If we extrapolate this over the 157,208ha of Greater London, by the using potential UA land allocation of 4.5% (equal to 7074.36ha), then we get a total figure of 134,554.33 tonnes of CO_2 saved, over a 259-day period. It should be remembered that this figure is relative to 27.87% of the total average vegetable consumption.

Table 15: CO_2 saved by UA, as a direct replacement for imported food.

A: Total tonnes CO_2 per 0.028 ha	0.53
B: Total tonnes scaled to one ha	19.02
C: Total tonnes of CO_2 for 8.53ha UA area (4.5% of total 191.34ha area)	162.24
D: Total tonnes of CO_2 for Greater London (row B X 4.5% of 157,208.00ha)	134,554.33

The food access map, overlaid onto the test site in illustration 37, Chapter 6, did not actually produce any results of its own, and was in fact used incorrectly in that the 500m circle around the Tesco's store was related to the whole UA area rather than just the UA within its circumference. This will be discussed later in the conclusion.

7.7. Yields Relative to Current Ground Maintenance and CO_2

As discussed in chapter 2, grounds maintenance equipment is of particular concern because of the high emissions factors, compared to other fossil fuel engines, and the fact that it is not covered by emissions regulations.

One of the most popular grounds maintenance machines, used by Southwark is the Commander 3520, as discussed in Chapter 2. We get some idea of the pollution caused by this machine by comparing the 1992.9 g/km CO_2 emitted by the Commander, to the Ford Focus, the UK's most popular car (Dial Direct, 2006), which produces 166g/km of CO_2, or 91% less emissions.

Taking the figure of 7805.3 grams CO_2 emitted per hectare for grass cutting, the total saving over the 8.53ha UA site would be 66,579.46g/ CO_2. This figure is be multiplied by 14 (weeks per year), as the grass is cut every two weeks, from March to September as shown in table 16.

Table 16: Estimated Emissions, Ransomes, Commander 3520

	Ransones Commander 3520	Cutting speed 3.2ha per hour/12.5km
a	Minutes per hectare	18.8
b	Minutes per km	0.21
	a x b (km travelled in 18.8 mins)	3.9km
c	Grams CO_2 per km	1992.90
d	Total Grams CO_2 per hectare (d = c x (a x b))	7,805.33
e	Grams CO_2 emitted over UA area (e = 8.53ha x d)	66,579.46
f	Grams CO_2 emitted for 14 week mowing period (f = e x 14 weeks)	932,112.41

Source: http://www.ransomesjacobsen.com/specifications

The figure of 932,112.41grams (0.93 tonnes) can be added to the CO2 emissions from food miles of 162.24 to give total emissions saved of 163.16 tonnes or 19.13 per hectare. It should be noted, that while it is simpler to express CO_2 figures alone within the calculation to allow a direct comparison with the food miles data, CO_2 alone fails to present a complete picture of total emissions for the ground maintenance equipment, because it does not take into account, nitrous oxides, carbon monoxide, hydro carbons or particulate matter, all of which contribute to greenhouse gas emissions (GHG), some at levels way above CO_2 alone[46].

However, getting a full breakdown of data for emissions from the Ransomes range of products was difficult as the data is not covered by emissions legislation and Ransomes and Kubota (who manufacture the engines), expressed commercial confidentiality towards releasing any engine tests they had undertaken. Notwithstanding this and with some degree of cooperation from Ransomes[47] and using online calculators (Environment Canada, 2005), the above figures are felt to be a reliable representation of the emissions from the Commander 3520.

It also follows, that not all the grass cutting would be done using the Commander 3520, as this is a large machine and would not be suitable for cutting smaller areas of grass. However, emissions from the smaller hand mowers, such as Ransomes EC Hydro Midsize[48], do not actually improve over the efficiency of the larger machines. The engine in the EC Hydro is a 15 hp engine which consumes 5.2 litres an hour. In one hour it will mow about 0.71 of a hectare and produce around 7kg of CO_2.

One solution could be the use of sheep as lawn mowers, as see in illustration 39, taken outside the central train station Hook Van Holland, showing the surrounding urban environment.

Illustration 39: Sheep as Lawnmower, Hook Van Holland

Source: The Author April 2006

46: Based on weight and a 100-year period, methane is a 21 times more powerful greenhouse gas than CO_2 and N_2O is 310 times more powerful. Some of the other greenhouse gases (hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride) have considerably higher global-warming potential values. For example, sulphur hexafluoride has a global-warming potential of 23,900. (http://www2.dmu.dk/1_viden/2_Miljoe-tilstand/3_luft/4_adaei/greenhouse_gases_en.asp)

47: Various emails and telephone conversations were had with both companies over a period of three months. While Ransomes were very helpful, the author was asked not to publish any data that they supplied, but it was checked against basic engine calculations, online resources and articles cited in chapter two and found to be consistent for CO_2 and NOx. However, it was not possible to produce data for the various components of NOx calculators (nitrogen monoxide (NO) and nitrogen dioxide (NO2).Also see above.)

48 http://www.ransomesjacobsen.com/specifications/b_municipal/ec_hydro_midsize.pdf

7.8. Analysis of Metro-Agricultural System

The reliability of the figure of 31.28 tonnes per hectare, obtained from the RHS allotment test and used to calculate the UA yields, should not be taken as an absolute over all conditions. For example, any UA system would take several years to mature, and would depend greatly on the skill of the grower.

This is particularly important to note given how labour intensive small scale food growing is. The RHS allotment test used one gardener and required 180 hours of gardening (or 22.5 days at 8 hours a day) over a 259 day period. Working full time, the gardener could tend about 8 allotment-size plots in the same period. Given that there are approximately 35 allotment plots to one hectare, it would require about 4.5 gardeners per hectare or approximately 37 gardeners for the total UA area of 8.53 hectares.

However, as each gardener would produce differing yields, this might making planning for food distribution difficult. Also it could be argued that this criticism is only relevant compared to our present food distribution system, dominated by the supermarkets, which demand a constant flow of cheap produce. Shifting to a local UA system would encourage consumers to be aware of the process of food production, where vegetables were seen as part of a natural process, full of variations. This process would also be underlined by the visibility of the UA systems in their neighbourhoods[49].

There is also the possibility that the yield per hectare is being underestimated as the Which? Report, discussed in chapter 4, states a yield of 40 tonnes per hectare, while UA in Havana has reached yields as high as 250 tonnes per hectare (Cruz and Medina, 2003). Considering the level of technology and resource directed at modern farming, it would not be surprising if a yield established in 1974 could not be bettered, some 30 years later.

7.9. Elephant, Burgess and Some Guinness

The results of the Elephant and Castle can be compared to the two other sites that were looked at. Table 17, which shows the total area of each site, together with a break down of the public and private areas in hectares and as a percentage.

Table 17: The Three Test Sites Compared

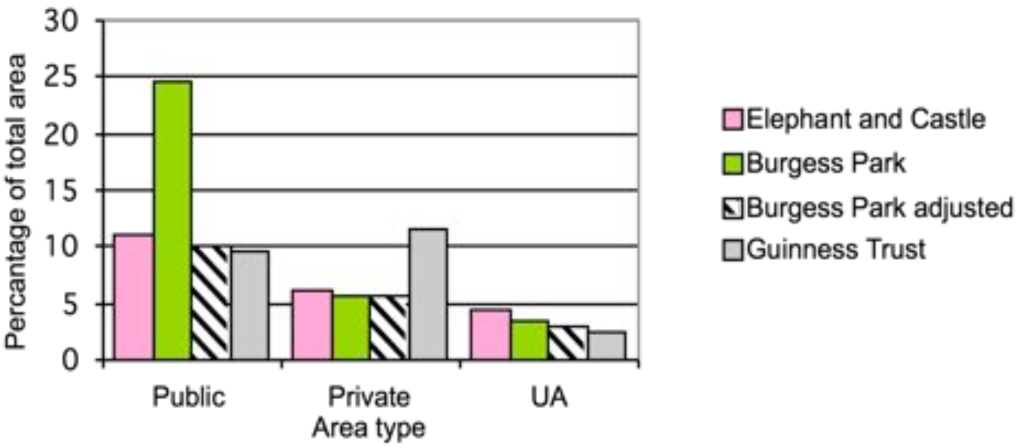
	Total Area	Public Grass	Private Gardens	UA
Elephant and Castle (ha)	191.34	21.39	11.88	8.53
Expressed as percent of 191.34 ha	100%	11.18%	6.21%	4.5%
Burgess Park (ha)	107.36	26.38	6.13	4.50
Expressed as percent of 107.36 ha	100%	24.57%	5.71%	3.40%
Burgess Park adjusted	(89.65ha)	(10.20%)	(5.71%)	(3%)
Guinness Trust (ha)	23.11	2.21	2.69	0.58
Expressed as percent of 23.11 ha	100%	9.56%	11.64%	2.6%

Elephant and Castle, Burgess Park and Guinness Trust Test Sites.

49: While UA systems are labour intensive compared to industrial agriculture, it would seem economic to employ 37 local people, to feed over 16,000 people. One figure that was not available is the number of people currently employed in 'mower gangs' by the local authorities in London. Perhaps all that is required is a period of retraining current staff in the science of vegetable growing, together with the development of UA shops for the system to work with very little change in current ground maintenance budgeting.

The row in table 18, labelled '*Burgess Park adjusted'*, refers to the results for the Burgess Park test area, together with its UA plots, removed from the total. This is because the park represents a large public green space and therefore makes a comparison difficult. As we can see from chart 5, when we display the results as a percentage of the total areas, there is a level of consistency between the results. The UA area of all three plots falls between 2.6 and 4.5% of the total area of each site. The public area also shows great consistency, ranging between 9.56 and 11.19% (using the adjusted figures for Burgess Park). Furthermore, the private areas, while having a larger range (5.71% to 11.64%) are still within the same degrees of magnitude as each other.

Chart 5: Comparison of the Three Areas



The chart shows the public, private and UA areas across the three sites

7.10. Range of Results Relative to Wider Picture

If the potential range of yields within the Elephant UA site is considered, starting from one hectare up to the full potential 35ha available, it is probable that productivity would reach 100% of the 956.67 tonne vegetable requirements of the UA test area at approximately 31ha. The CO_2 emissions can also be calculated as a range and if we start with a yield of 10 tonnes per hectares, the possible CO_2 saving would be 191.30 tonnes, reaching 4,782.50 tonnes if the yield reached 250 tonnes, quoted in the review on Cuban UA, Chapter 4.

Relating these figures to the wider picture is difficult, because the UK emissions data do not have to take into account emissions caused by food transported by all methods, outside the UK. DEFRA (Watkiss et al, 2005), states that the total CO_2 emissions for the UK is 564,667,000 tonnes CO_2, of which 3.4% (19,062,000 tonnes are UK food transport related). It should also be remembered that all the figures quoted in this thesis do not include CO, NO_X, SO_2 or PM and VOCs. The figure of 134,554.33 tonnes of CO_2 estimated for Greater London from table 16, while inconclusive, is with degrees of magnitude, relative to CO_2 emissions for the UK, calculated in millions of tonnes.

Coming back to one of the primary statements of this thesis; the need to see food production as a source of renewable energy and create a system to evaluate it, another way to evaluate the results is to compare it to how other renewables perform, in relationship to architecture. The city of London installed 11 Combined Heat and Power (CHP) plants in a variety of buildings, with a winter heating load of 11 megawatts. The use of these CHP units also provided 3.5 megawatts of cooling power and saved an estimated 7,000 tonnes of CO_2, in the year 2000 (City of London, 2006).This can be compared to the figure quoted above of 4782.50 tonnes of CO_2 saved per hectare if the yield reaches 250 tonnes per hectare. Over the Elephant UA area of 8.53, that would equate to 40,794.73 tonnes of CO_2 saved, up to 65,089.83

tonnes of CO_2 saved if the combined Elephant, Burgess and Guinness sites of 13.61 hectare were used

7.11. Analysis of Method

The GIS system, chosen because it is ubiquitous across many organisations, performed well, with few if any exceptions. However, the use of downloaded OS raster maps and the use of the Adobe illustrator software to create vectors, was a difficult and time consuming process, with many technical problems. While all the issues were eventually overcome, the process sapped a large portion of time out of the thesis that would have been better spent on site visits. Suitable alternatives need to be investigated. The Google Earth software and the process of comparing it to the OS data was a central part of the process and it performed well, both as part of the method and as a piece of software.

The site visits and photograph were vital to the process and uncovered a great many details about the possibility for UA within the area as well as a broader understanding of the way urban green space is planned (or is not planned at all). This stage of the method balances the process from being a top down method, similar to the urban master-planning that has happened in the postwar years, to being an inclusive method that worked from the ground up. When comparing the full, seven-stage method used at the Elephant, to the shorter method adopted for the two other test sites at Burgess Park and Guinness Trust, it was clear that the full process was much more time consuming than the shorter method, that included the site visits and photography. It is not clear from the results, whether the site visits lead to more UA spaces being created or not and this type of result was not apparent by comparing the three test sites[50].

The method as a whole is slow and time consuming, which together with the requirement to feed information back, may make it unpopular with organisations that have to balance time and money. Although, as with all technical process, the method will speed up as it gets refined[51].

The method also needs to address other local issues, which might affect the installation of a UA system. These could be age-related, or influenced by ethnic identity, or gender specific. There is also the question of people's consumer habits, and commercial pressures, which might drive a free market UA system into a similar direction as farming has been taken.

Beck, Quigley and Martin, who evaluated food production in four different types of urban landscape over a five-year period, concluded that installing "food producing landscapes alone may not substantially alter the heterotrophic nature of cities" (2001, p.206), because of the external costs of manufactured materials together with labour and importing plant material. In other words, if the food-producing activity is not placed within the larger context of the city or neighbourhood, it will not offer any benefits in terms of a shift from heterotrophic to autotrophic sustainable cites.

7.12. Summary

The results show that while it is possible to retro fit UA within London and measure its yields relevant to the density, it was difficult to give an accurate picture of the total CO_2 that such a system might save.

Chapter 8 will discuss these points further when it presents the conclusions of the thesis, together with relevance to the wide picture, followed by an outline of its limitations and possible further work.

50: It should also be noted that the author was already very familiar with the entire test area, as he has lived there for 13 years. Therefore it could be argued that site visits, albeit brief, had already been made to the Guinness Trust and Burgess Park sites.

51: The author would like to state that, while it is difficult to place a time period on how long the method took, a disproportionate amount of time was spent on setting up the software stream and learning GIS software.

Chapter 8
Conclusion

8.0. Introduction

This chapter will conclude the thesis by looking at the four main areas of research into UA practices:

- The measurement of urban green space and its potential for UA
- The potential yields of vegetables and their relationship to the density
- CO_2 emissions from food miles and ground-maintenance activity
- Assessing the method and research design of the thesis

The thesis will also return to the key questions asked in the introduction, which were:

- Do we have enough land in our urban centres to support UA?
- Can a method be developed to enable food to be seen as a renewable energy?
- The consideration of grassed or open land a key resource of that renewable energy
- Can UA production be embedded into planning and architecture?
- The method developed, has to relate yields to surrounding density

8.1. Green Space and Urban Planning

The results state that there is 35.53ha of open space within the 191.34ha of the Elephant test site. Within this 35.53ha of open space, 8.53 can be converted to UA practices, while still preserving current leisure and recreational activities. Therefore, the case for potential urban agricultural activities within the Elephant and Castle test area, together with the land availability question, is clearly answered from the results of the GIS system.

The GIS data shows that there is an abundance of urban space, ranging from traditional parks, to grass forecourts surrounding postwar developments as well as derelict land together with existing UA practices, such as allotments and city farms. However, the data also shows that there is a great deal of grassed space which is an afterthought, highly atomised and undocumented, with little or no identity or categorisation of its own.

The results show a great degree of consistency between the both the UA space available (between 2.6 and 4.5% of the total area of each site) and the total public area (ranging between 9.56 and 11.19% of the total area of each site). Therefore it can be concluded that the method of measuring land is reliable and consistent at the digital level, with regard to the identifying of urban spaces by type. However, without the site visits, the Guinness Trust and the Burgess Park data could be questioned because it does not take into account current land use practices.

The method has identified an extra 7ha of open space not accounted for by Southwark Council on their GIS data and 16.06ha of extra open space not on the GLA data. Therefore, in answer to the question of land availability: the achievement of the GIS process is in identifying and collectivising the various fragmentary open and grassed sites. This allows the creation of a critical mass of landscape, which enables this lost urban resource to be given a real value by translating it into food-energy productions.

The value of the food-energy yield is arrived at by measuring it against the surrounding Elephant and Castle area, where it would provide 27% of the average vegetable requirements and representing a significant contribution to food security.

Furthermore, the work identifies UA as a powerful tool in transforming the discourse of urban landscape planning, by allowing us to see beyond the traditional city map, drawn around the established iconography of roads, buildings and parks, towards a fluid map of the city, the dynamic urban ecosystem and connecting people to their location. Far from being an oxymoron, UA could slip seamlessly into the urban landscape.

However, when planning UA systems there is an apparent contradiction between the public spaces and those which are owned either privately or by bodies such as the Guinness trust. One of these contradictions is the issue of individual versus collective organisations, not just on a level of efficiency and shared resource, but also as a response to wider environmental issues (Gaynor, 2006).

Urban centres have the potential for collective response because so much of the surrounding infrastructure, together with any problems, is a shared experience. However, this potential can be over ridden by the sense of independence that private ownership gives people, which is ironic given that the practice of UA is ultimately about the greatest independence we could achieve – that of food security. It would be a challenge for any organisation, planning UA, either as a retro fit or as a new building to address the issue of UA and social organisation.

8.2. Yields, Density and the Energy Question

The results show that with an expected yield of 31.28 tonnes per hectare, the 8.53ha UA land will yield 27% of the 16,245 residents' average vegetable requirements, over a 259 day period. It was one of the stated objectives of this thesis that food, together with urban green space, needs to be treated as an energy source, in the same way we can measure oil or wind.

The results, however, need to be analysed further so that more account can be taken of the distribution and fragmentation of space as well as solar aspect. It is all very well collecting the space together, but the results need to reject some of the smaller of spaces that are perhaps too isolated or some of the spaces that are over shadowed by the surrounding buildings.

The research has shown that it is possible to give urban landscape a value, by calculating yields per square metre per person as a percentage of their daily requirement and then relating this output to the surrounding density and architecture. Also, by converting the yield to a square metre per person, in this case $0.5m^2$ for each resident, the work has established a benchmark which could just as easily be applied to rooftop gardens and grassed areas, thus enabling sites that do not have access to outdoor space the opportunity to develop UA practices.

However, while the method provides a clear process, the data used could be questioned further. It was clear from the discussion in micro-agricultural systems that yields per hectare could vary considerably and therefore a range of results should be considered. The example of Cuba, discussed in Chapter 4, shows that a variety of UA practices were adopted in response to growing food in cities, each with its own efficiency. Some sites were more productive than others and the productivity increased over time.

If UA is seen as part of the urban ecology, its resources will vary depending on its surroundings, and there might not be equity across the city. While UA needs to be reliable, in the same way other renewables are, if it is to take up valuable urban space, it also needs to address issues of environmental and social impact as part of the triple bottom-line argument. Therefore, perhaps a broader expectation of its yield potential should be balanced against these less quantifiable areas. This is not to say that the yield of 31.28 tonnes per hectare was over-ambitious, but that yields will vary due to expertise, plot size, solar aspect, local resources, micro climates, and social organisation and so on, and that the yield represents an average over a given area.

The idea of increasing urban densities is questioned by the findings of this thesis because the discussion of saving energy by creating a compact city does not take into account present energy used in food delivery, nor its considerable and rapidly increasing. Therefore, the necessity to find urban land to re-localise food production, in the post oil age could be severely limited, coupled with too great a population rise.

8.3. CO_2 Emissions

While the measurement of urban space together with yields per hectare represents a system of analysis which is self verifying, the measurement of CO_2 emissions, for both food miles and grounds maintenance, required the outsourcing of almost all the data and can therefore be considered less reliable. They are included for the sake of completeness, in that this data is vital to a balanced model of a section of an urban system, and they work merely to indicate the spheres of influence against which UA practices must exist and be measured.

Moreover, food miles is not an exact science, and while several different models have been referenced in this thesis, all in some way fail to encapsulate the complexities of modern food delivery systems. While this might make the figures for food miles questionable, especially since the UA model developed here is theoretical and the food miles indicator used a simple one, what is clear is that UA can and should be used to reduce the ever-increasing transportation of food, provided that local models are adopted that stress carbon-zero transport models.

While on the one hand the contribution that food transport makes to climate change is a well-debated subject, on the other hand the assumption would be that the park system makes an all-round positive contribution and it would seem counter-intuitive to suggest that the grass, trees and flowers of our parks are causing more environmental damage than good. However, the results for emissions from lawnmowers, and associated grounds-maintenance equipment, while not conclusive in themselves, do suggest that the story is not straightforward and the parks system is out of date and not accounted for in the climate change debate. While they have been included here, as with food miles, as an indicator of influence to complete a model and would certainly require further development into a more complete system of analysis.

However, what can be concluded is that grass represents a history of environmental manipulation; another monoculture imposed on the landscape, which needs to be questioned, both as a form of ecological censorship, but also as unsustainable in a post-oil age. Certainly, one starting place would be the inclusion of these heavily polluting engines into emissions regulation.

8.4. Methodology and Research Design

The method was more successful where it was producing its own data, such as land area measurements and potential UA sites, than when it was importing data from outside agencies, such as DEFRA (Watkiss et al, 2005) or Sustain (Jones, 2002). The problem is not that the imported data is unreliable (in fact the DEFRA data is extremely reliable, given how transparent their methods are), but that one set of data was site specific and the other was national, averaged out and made some large assumptions.

Following on from this and considering the seven stages of the method listed below, we can conclude that stages one to five of the process, given the criticism already stated were reliable in testing a UA model.

The seven stages:

- **Stage 1** Digital map creation
- **Stage 2** Qualitative (site visits/photography/interviews) and quantitative (GIS data/satellite/area types) data collection
- **Stage 3** Division of infrastructure using qualitative and quantitative data
- **Stage 4** Separation into food-growing and non-food-growing areas
- **Stage 5** Assessment of yields
- **Stage 6** Comparison with current food imports, CO_2 and grounds maintenance
- **Stage 7** Results, analysis and feedback

The reliability of stage 6 has more to do with the food miles calculation not reflecting the whole process. It can be concluded that by not transporting the food listed in the RHS allotment experiment (from the various locations listed in appendix 3) a reduction of CO_2 emissions by 532,887.80 grams would be achieved. But the thesis does not prove that UA practices, within the present commercial climate of supermarket dominance, would necessarily stop this food being imported. Also, the subtraction of CO_2 caused by food miles needs to be modelled against other systems, such as local box schemes or farmers' markets (Viljoen et al, 2005), i.e. local food delivery systems that currently exist and against the possible CO_2 released in a potential UA practice.

The research design called for the results to feed back into the both the original GIS stream and to local users, however It is clear from chapter 6 that no local users were interviewed for reasons already discussed. Furthermore, since the completion of the primary data collection, no data has been returned to either Southwark Council or the GLA. It is therefore not possible to draw conclusions stage 7 of the method and the subject will be discussed further in chapter 9.

8.5. Summary

The conclusion will now be discussed in the context of its limitation and to identify how the method could be developed as part of further work.

Chapter 9
Limitations And Further Work

9.0. Introduction

This chapter will discuss the limitations of the results, analysis and conclusion, and suggest a program of further work for the method.

9.1. Limitations and Further Work

9.1.0. Yields

Further work would involve working with small scale food producers, both here and in established UA systems abroad, so that more accurate figures for yields can be established, beyond the RHS figures for 1974. There would also be the opportunity to look at growing techniques, crop varieties and assess the energy inputs and waste outputs of potential UA systems.

The obvious test would be to establish a UA test bed with an urban environment and calculate the yield over several growing seasons. Embedding such a test in an urban environment, would also allow for a better integration of the architecture into the growing process, so that techniques such as heat recovery might help bridge the gap in the growing season, which was set at 259 days because of the RHS experiment.

The allotment system only represents one aspect of food growing and as an annual system it is labour intensive. Perennial food systems are less labour and energy intensive, such as Plants for a Future (PFAF), which has developed a system of wildlife gardening which seeks to mimic the look of natural woodland as well as provide food crops (Fern, 1997). In doing so it combines a space for nature as well as resources for humans.

9.1.1. Foods Miles and Food Access Mappping

The food miles calculation needs to be expanded to include the farm process as well as an allowance for the use of fertilizers, the processing and packing, as well a greater understanding of the distribution process. This should be done relative to the area being studied and relate directly to the local shops and peoples access to them. The UA system could then be compared to this, so that input and output calculation for energy use.

9.1.2. Existing trees

The existing tree cover, was completely ignored when the UA units were planned across the test site. Tree protection orders are quite standard and cover most urban trees, and the probability of removing trees from the landscape would be slim. One solution is to farm the trees, so that their wood becomes a fuel source, and that any replacements could be made up with food producing trees. For example, the harvesting of trees has been standard practice in Telford New Town and it has been awarded FSC status for managing urban forests since 1998 (Winder, 2001).

9.1.3. The feed back loop

The research design called for the results to be feed back to both the GIS stream and local users. It is a clear limitation of the method that neither of these has happened. An important aspect of further work is that a form of local engagement be designed and implemented. This could be a questionnaire, interviews, or a series of photomontages, showing how a possible site could be laid out.

9.1.4 Animals and fruit

This thesis only dealt with vegetable production, mainly because the yields were taken from the RHS vegetable allotment alone, but also because vegetable production is more efficient at delivering food and requires less processing, in particular refrigeration. However, animals could be considered as part of a possible extension of an UA ecosystem, as more animals, duck s for example are efficient at keeping pests such as slugs at bay. This would provide an organic solution to a situation that might otherwise tempt a chemical (oil based) response. Also animals could provide food during the winter months when crop might be low.

Fruit should also be considered as this is generally a perennial crop that requires less maintenance than the usual annual crops and a great many of the ornamental shrubs that fill our current parks could be replaced with fruit bushes.

9.1.5. Method

One of the difficulties the work faces is that there are no benchmarks against which to measure the results. This is partly because the analysis does not try and create a single quantifiable figure out of the research and because, as discussed above there is no coherent national standard for evaluating open space. Extending the test system to include some of the recommendations above would undoubtedly mean the system would develop aspect of a life cycle analysis (LCA). however, as was shown from the conclusion, the method should try and gather as much material as is possible from the local site, rather than import averages or national data.

Appendix

Appendix 1: Ransomes Commander 3520
Ransomes Commander 3520 Accessed on line:
http://www.ransomesjacobsen.com/specifications/b_municipal/commander_3520dx_lgtt010_rev2_with_lube.pdf (10/06/06)

PRODUCT SPECIFICATION SHEET

Commander 3520 **LGTT010 Product Code** **ZE Serial Numbers**

MACHINE DETAILS

Engine Details

Manufacturer	Kubota
Engine model	V2203 - B
Engine type	4 cyl. diesel
Horse power HP	51
Horse power KW	38
Cubic capacity	2197
Engine RPM max	2800
Engine RPM min	1400
Fuel type	No.2-D Diesel
Quantity	60 litres

Battery information 665 Battery dimensions

Dimensions

Length	310 cm	122.05 inches
Cutting width	350 cm	137.80 inches
Transport width	200 cm	78.74 inches
Height	145 cm	57.09 inches
Weight	2300 Kg	5066.08 Lbs

Servicing (Fluids)

Engine Oil:	Grade – 10W-30	Quantity	9.5 Litres
Hydraulic oil:	Grade – Shell Tellus 46	Quantity	52 Litres
Coolant:	50/50 Water/antifreeze mix	Quantity	6.8 Litres
General Grease:	Grade – Shell Darina R2		

Wheels and Tyres

Tyre pressure 14.5 psi Ground pressure 14.5 psi

	Part No	Dimensions	Ply	Tread
Front Wheel Standard		26 x 12 - 12		Multi - Trac
Rear Wheel Standard		23 x 10.5 - 12		

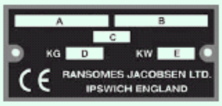
Noise & Vibration

Operators ear level (sound pressure)	90dB dB
Bystander level (sound power)	105dB dB
Whole body acceleration level X	0.01
Whole body acceleration level Y	0.0195
Whole body acceleration level Z	0.0315

Publications

Operators book	24345G
Parts book	
Workshop manual	

Product Identification



A – Commander 3520
B – ZE000301 (e.g.)
C – 2004
D – 2300Kg
E – 38 KW OR serial Number Plate = 0 LGTT010 01234

Cutting

Floating Head

Cutting performance 3.2 ha/hr at 12.5 km/hr

Bottom blade	Thickness	Height of Cut
Standard	12.5mm	13mm- 35mm
Option 1	6.35mm	9 mm - 30 mm

Cylinder	
Diameter (max – min)	197 mm – 178 mm
No. of knives available	8/11

Fixed Head

Cutting performance 3.2ha/hr @ 12.5 km/hr

Bottom blade	Thickness	Height of Cut
Standard	12.5 mm	13 mm - 51 mm
Option 1	6.35mm	N/A – 30mm

Cylinder	
Diameter (max – min)	254 mm - 235 mm
No. of knives available	6

RANSOMES JACOBSEN A Textron Company

Website: www.ransomesjacobsen.com - Issue 2

CUSTOMER ONE

PRODUCT SPECIFICATION SHEET

Commander 3520 **LGTT010 Product Code** **ZE Serial Numbers**

SERVICING

Description	Type	Qty
Engine Oil:	Grade – 10W-30 Quantity	9.5 Litres
Hydraulic oil:	Grade – Shell Tellus 46	52 Litres
Coolant:	50/50 Water/antifreeze mix	6.8 Litres
General Grease:	Grade – Shell Darina R2	

Interval	Description
Daily/ Every 8 hours	Check oil level Check/Clean air filter element Check Coolant level Check and clean bug screen Check tyre pressure Check hydraulic fluid level Check engine bay for debris
Weekly / Every 40 hours	Check nuts and bolts for tightness Check hydraulic fittings for tightness Check battery condition Lubrication with Shell Darina R-2 grease Rear Axle Centre Pivot Steering rams-Inner Pivots Steering ram rod-ends Steering track rod, rod-ends Unit pivot brackets Lift arm pivots Cutting cylinder bearings
First 50 hours	Change oil Change oil filter cartridge
Every 100 hours	Check/Clean air filter element
Every 200 Hours	Change oil Replace oil filter cartridge
Every 400 Hours	Replace air filter element Replace plastic inline fuel filter Replace fuel filter cannister
Every 600 Hours/ End of Season as required	Replace hydraulic filter (charge) Replace hydraulic filter (suction) Change hydraulic oil Change coolant

HYDRAULICS and TESTING

	Litres/Min	Relief Valve pressure (psi)	(Bar)	Test Port Number Or location
Transmission				
Forward	123	5037	345	
Reverse	123	3046	210	
Case	n/a			
Cutting				
Forward	65.6	3046	210	
Reverse	65.6	3046	210	
Charge	39.6	283	20.5	
Steering & Lift				
Steering	8	1800	124	
Lift	9.1	3046	210	
Weight transfer		60 - 500	4 - 34	

Wheel & Cylinder speeds

Transport Speed	25 km (15.53 mph)
Cutting speed	12 km (7.45 mph)
Reverse speed	6 km (3.73 mph)

Appendix 2: NSALG

NATIONAL SOCIETY OF ALLOTMENT AND LEISURE GARDENERS LTD
YOUR GARDEN PLOT – WHAT IS ITS VALUE TO YOU?

During 1975 the Royal Horticultural Society maintained a 30 feet by 100 feet vegetable plot at Harlow Carr, with the aim of showing how vegetables for a family of 4 could be provided. The 3 year crop rotation was adopted and most of the work on the plot was carried out by the garden apprentice. Approximately 180 hours work went into the feature. First sowings were made on 9th March in the cold frame. One 22nd November the total value of the produce at the 10 average shop prices was £219.65, with still plenty of winter crops, leeks, onions cabbage, kale, parsnips, broccoli and brussel sprouts still on the plot.

Yields from this plot are given below. You can ascertain the present retail prices for each variety of vegetable, entering it in column 3. Simple arithmetic will give you an approximate total yield of your plot in money terms. It will astound you.

CROP	WEIGHT OF HARVEST	RETAIL PRICE	VALUE
Carrots	146 lbs		
Parsnips	23 lbs		
Beetroot	156 lbs		
Lettuce	270 heads		
Radish	42 bunches		
Broad Beans	78 lbs		
Peas	37 lbs		
Cabbage	234 lbs		
Brussel Sprouts	27 lbs		
Turnips	46 lbs		
Runner Beans	116 lbs		
French Dwarf Beans	36 lbs		
Marrows	28 lbs		
Courgettes	53 lbs		
Onions	57 lbs		
Spring Onions	45 bunches		
Potatoes	208 lbs		
Leeks	34 lbs		
Celery	57 heads		
Spinich	11 lbs		
Spinich Beet	145 lbs		
Sweetcorn	38 cobs		

PLUS
Gooseberries
Blackcurrants
Rhubarb
Cucumbers

Appendix 3: Eating Oil, Jones, 2002

CO_2 EMISSIONS OF IMPORTED VEGETABLE
58 per 0.6kg (Spain - Lorry)
58 per 0.6kg (Spain - Lorry)
43 per 0.4kg (Italy – Lorry)
58 per 0.6kg (Spain - Lorry)
58 per 0.6kg (Spain - Lorry)
10 per 0.5kg (Netherlands - boat)
2253 per 0.6kg (Zimbabwe - plane)
58 per 0.6kg (spain - lorry)
10 per 0.5kg (Netherlands - boat)
43 per 0.4kg (Italy – Lorry)
2327 per 0.4kg (kenya - plane)
2327 per 1kg (Kenya – plane)
58 per 0.6kg (spain - lorry)
10 per 0.5kg (Netherlands – boat)
414 per 1.8kg (New Zealand - boat)
10 per 0.5kg (Netherlands – boat)
43 per 0.4kg (Italy – Lorry)
10 per 0.5kg (Netherlands – boat)
10 per 0.5kg (Netherlands –boat)
10 per 0.6kg (holland – boat)
10 per 0.5kg (Netherlands – boat)
3001 per 0.5kg (USA - plane)

Appendix 4: Ford Focus.

Accessed at http://motoring.independent.co.uk/road_tests/article844543.ece (10/06/06)

Performance & Emissions

	CO2 emissions	Urban	Extra Urban	Combined
1.6	156 g/km	31.7 mpg	49.6 mpg	40.9 mpg
1.6 (Ti-VCT)	160 g/km	31.7 mpg	53.3 mpg	42.8 mpg
1.8	172 g/km	29.1 mpg	49.6 mpg	39.8 mpg
2.0	176 g/km	28.2 mpg	50.4 mpg	38.7 mpg
1.6 (TDCi) stage 4	127 k/gm	47.1 mpg	60.9 mpg	58.9 mpg
1.6 (TDCi) stage 3	129 g/km	44.8 mpg	66.9 mpg	57.6 mpg
1.6 (TDCi) stage 4 + DPF	129 g/km	44.9 mpg	68.9 mpg	57.6 mpg
1.6 (TDCi CVT auto)	151 g/km	39.8 mpg	57.6 mpg	49.6 mpg
2.0 (TDCi) stage 3	148 g/km	37.7 mpg	62.8 mpg	50.4 mpg
2.0 (TDCi) stage 4	154 g/km	37.2 mpg	58.9 mpg	48.7 mpg

Appendix 5. London Ecology Unit

THE AMOUNT OF EACH KIND OF GROUND COVER IN GREATER LONDON

By D.G. Dawson & A. Worrell.

INTRODUCTION

This report gives the results of an analysis of aerial photographs of Greater London to measure the extent of various categories of ground cover. It was undertaken because we had no recent statistics on a London-wide basis to evaluate the importance of habitats such as those found in the gardens of suburban dwellings when summed over large areas of London. The statistics should be useful also for indicating how much of London's surface is devoted to the hard surfaces of roads, car parks, etc.

METHODS

The analysis was made on a comprehensive set of black and white, vertical aerial photographs taken by 'aerofilms' for the Greater London Council, largely in mid August 1981, but with some later flights up till early 1982. These photographs were used because they were the most recent comprehensive coverage at the time the study began. The photographs for most of London were printed at approximately 1:5 000, but those for a large sector in west London, where flying had to be higher because of Heathrow approaches, were printed at approximately 1:10 000. The work was begun by D.G. Dawson, continued by J. Holt and finished by A. Worrell; we thank John Holt for his contribution to the study.

61 photographs were selected for analysis, each being the nearest to a particular intersection of national grid lines within Greater London. This systematic sampling method was preferred to the usual random method, because it yields a more precise estimate of the London-wide position, provided no ground features are distributed systematically in relation to map grid lines.

On each selected photograph a transparent overlay with 100 sample points was used. This covered about 1/4 km^2 on the 1:5 000 photographs and about one km^2 on the 1:10 000. The ground cover directly under the centre of each point was identified into one of the categories listed in the table of results.

The results for each photograph were therefore an assessment of the percentage ground cover afforded by each of the categories found. These were averaged over the 61 photographs to give the percentages in the 'mean' column of the table of results. The standard error of this mean was also calculated ("S.E." in the table) and the range of values over the 61 photographs is also given. As percentages rarely give a good fit to a normal distribution the standard errors of the table should not be used to calculate confidence intervals. The lower confidence limit will lie nearer the mean than normal theory would indicate and the upper one further away. Nevertheless the standard errors indicate that differences of the order of one to three percentage points may be sampling errors, rather than real. It would be wrong, for example, to take grassed airport verges as half the area of cemeteries in London.

ACCURACY AND BIAS

Apart from the aspects of statistical sampling discussed above, there were other considerations contributing to accuracy and bias. These involve the determination of the category (for example discriminating scrub from woodland). Generally there were very few such difficulties, but one of significance is that two of the three people making the judgements were unfamiliar with London nature conservation areas (those designated under statutory provisions or in planning documents) and doubtless missed some of the smaller ones. The larger nature conservation areas (such as Richmond Park and the Inner Thames Marshes SSSIs) account for most of the total, so the bias is probably not large. Especially on the 1:10 000 scale it was sometimes difficult to be sure whether a point fell on a small feature (such as a footpath or a street tree) or on the surrounding area. This has probably introduced a small bias. Nevertheless it is considered that the variation from photograph to photograph was much larger than any of these likely biases, so that the statistical standard errors of the table should be a good indication of the reliability of the estimates.

THE PERCENTAGE OF EACH CATEGORY OF GROUND COVER IN GREATER LONDON

GROUND COVER	MEAN	S.E.	RANGE (Min & max over the 61 photographs)
SOFT SURFACES			
Gardens of private dwellings	19.3	2.1	0-50
Parks	7.8	1.5	0-55
Farmland	6.7	2.8	0-99
Rough grass and scrub	3.7	1.2	0-42
Golf courses and driving ranges	3.2	1.4	0-62
Sports pitches	3.1	0.7	0-25
Tree line or avenue away from a road	2.5	0.5	0-16
Designated nature conservation areas	2.4	1.2	0-54
Woodland	1.9	0.8	0-42
The Thames	1.8	1.3	0-79
Rivers (except the Thames) & ponds	1.6	1.1	0-68
Grounds of schools & other institutions	1.5	0.2	0- 9
Roundabouts, road verges, etc	1.4	0.3	0-13
Street trees	1.3	0.2	0- 8
Allotments	1.2	0.5	0-20
Common green spaces around flats, etc	1.1	0.2	0- 6
Railway verges	1.0	0.3	0- 8
'Waste' ground	0.9	0.3	0-15
Well tended cemeteries & grave yards	0.7	0.4	0-20
Airport grass verges	0.3	0.3	0-17
Nurseries	0.3	0.2	0- 8
TOTAL SOFT SURFACES	63.7		
HARD SURFACES			
Houses and flats	11.7	1.1	0-36
Roads (excluding verges & pavements)	8.5	0.7	0-23
Car parks & other hard standing	5.1	0.6	0-18
Commercial & school buildings	4.0	0.9	0-40
Pavements (roadside footpaths)	3.7	0.5	0-14
Outbuildings (to private dwellings)	1.6	0.2	0-10
Rail lines,	0.7	0.2	0- 9
Airport runways	0.6	0.6	0-37
Hard sports surfaces	0.4	0.1	0- 3
Airport buildings	0.1	0.1	0- 4
Railway stations	0.1	0.0	0- 2
Churches	0.1	0.0	0- 1
TOTAL HARD SURFACES	36.6		

 Sept 1992 8422/d92a Page 2

Appendix 6: Email correspondence with NSALG

Email correspondence with Geoff Stokes
National Secretary, NSALG. Email: E-mail: geoff@nsalg.org.uk 31/03/06

Our survey showed that the main size is ten rod (30 x 100 feet), The Survey was conducted only for England and showed that there were 300,000 plots on 7800 sites with a total acreage of 25,393
At the time of the survey there were 43000 vacant plots but there were also 10000 people identified on waiting lists. From this, it is reasonable to assume that there are approx 330000 plots in the UK. This equates to one plot for every 65 households.

We do not have any other information on the RHS trial plot, but we believe it was used in a similar manner to normal allotment gardening otherwise it would not have been a fair trial.

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