UNIVERSITY OF BATH

Radical Cultivation:
a mega-structural approach to Urban Cultivation

DESIGN STUDIO 6.2

This is a thesis report submitted by Kan-chane Gunawardena towards the degree of Master of Architecture at the University of Bath, Department of Architecture and Civil Engineering. May 2009.

Preface

The precursor to this design thesis was presented by a written thesis submitted last November, titled as *The Instance of a Dwelling* (Gunawardena, 2009). This thesis investigated *dwelling* as an essential aspect of our understanding of being-in-the-world, and addressed the intrinsic desire for a 'rooted dwelling'. It posited that human beings strive for a reconciliation between their inner world and the natural outer world. The project illustrated this reconciliation as an interplay between anthropocentric order and the natural order, by juxtaposing the complex arrangements of a subject’s abode with that of a vast garden beyond. The thesis contended that human existence is a constant process of enquiry and response between these two essential orders, ultimately leading to a reconciliation of the subject’s being-in-the-world, which defines their sense of 'rootedness’.

The past century has witnessed a multitude of developments and paradigm shifts in search of defining a more meaningful existence. The perception of the world and approaches to *dwelling* as a result have undergone significant transformations and redefinitions. Emerging concerns and crises have prompted a re-evaluation of conventional lifestyles, and posed challenging objectives to ensure a better future for succeeding generations. The oil crises of the 1970s (1973 and 1979 oil shocks), as well as the recent Global Financial Crisis (2007-08), have all underscored the necessity for cautious resource consumption, as well as more stringent management of processes to ensure sustainable human habitation and settlement growth.

This design thesis explores this new paradigm in urban habitation. It examines a mode of *dwelling* that demands prudent resource consumption to continue and self-sustain the vitality of the city. Thus, it is considered as an extension and a progressive step from the written thesis, aiming to comprehend the modern challenges of dynamic transient urban *dwelling*, and how anthropocentric order can be reconciled with the natural order to achieve a degree of self-sufficiency...

Abstract

... this design thesis aims to explore the challenges associated with implementing an agenda of urban cultivation within the context of central Redcliffe, utilising a 'mega-structure' as the principal delivery infrastructure...

DS 6.2 is the final design thesis report that delves into the evolving dynamics of habitation and urban living. As the traditional concept of rooted dwelling gives way to increasingly transient lifestyles, modern urban residents face a reality where permanence in habitation is increasingly viewed as a luxury. This thesis examines the emerging paradigm of transient dwelling, exploring the challenges brought about by modern mobility and its effects on the urban experience. In parallel, the report investigates the growing shift toward self-sufficiency and sustainable living, with a particular focus on hydroponic cultivation. As urban environments often lack the space and conditions necessary for traditional farming, hydroponics presents a promising solution for controlled cultivation within cities. This thesis advocates for the integration of hydroponic systems into urban infrastructure and architecture, not as mere aesthetic features but as functional solutions that support sustainable urban living and enhance food security. Through the promotion of hydroponic integration within the built environment, this thesis report contributes to ongoing discussions surrounding the role of innovative agricultural practices in shaping the future of urban spaces.

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BBC

Global crisis 'to strike by 2030'

By Christine McGourty, Science correspondent,
BBC News, 19 March 2009.

Growing world population will cause a "perfect storm" of food, energy and water shortages by 2030, the UK government chief scientist has warned. By 2030 the demand for resources will create a crisis with dire consequences, Professorless John Beddington (Professor of Applied Population Biology at Imperial College, London) said. Demand for food and energy will jump 50% by 2030 and for fresh water by 30%, as the population tops 8.3 billion, he told a conference in London.

Climate change will exacerbate matters in unpredictable ways. "It's a perfect storm," Professor Beddington told the Sustainable Development UK 09 conference. "There's not going to be a complete collapse, but ***things will start*** *getting* ***really worrying if we don't tackle these problems."*** *He said the looming crisis would match the current one in the banking sector. "My main concern is what will happen internationally, there will be food and water shortages". "We're relatively fortunate in the UK; there may not be shortages here, but we can expect prices of food and energy to rise."*

The United Nations Environment Programme predicts widespread water shortages across Africa, Europe, and Asia by 2025. The amount of fresh water available per head of the population is expected to decline sharply in that time. The issue of food and energy security rose high on the political agenda last year during a spike in oil and commodity prices.

Professor Beddington said the concern now - when prices have dropped once again - was that the issues would slip back down the domestic and international agenda. "We can't afford to be complacent. Just because the high prices have dropped doesn't mean we can relax," he said. Improving agricultural productivity globally was one way to tackle the problem, he added. At present, 30-40% of all crops are lost due to pest and disease before they are harvested. We have to address that. We need more disease-resistant and pest-resistant plants and better practices, better harvesting procedures. "Genetically modified food could also be part of the solution. We need plants that are resistant to drought and salinity - a mixture of genetic modification and conventional plant breeding. Better water storage and cleaner energy supplies are also essential. The problem could not be tackled in isolation, he added. (McGourty, 2009)…

1.0 Mega-structural approach to Urban Cultivation

1.1 A thesis for Urban Cultivation

The rise in global population is no longer merely a statistical concern for economists and politicians, but a manifest reality in towns and cities worldwide. Over the past few decades, urban areas have experienced unprecedented growth, leading to an ever-increasing demand for resources necessary for daily operations. As the UK Government Chief Scientific Adviser, Professor John Beddington had warned, food and energy demands have already reached alarming levels, and by 2030, these demands may outstrip the existing resource supply (McGourty, 2009). Addressing this issue first requires acknowledging the problem. Denial he argued, will only exacerbate the problem, and eventually lead to catastrophic failures. Secondly, he emphasised the need to prepare and develop better strategies to cope with unprecedented future demands. This entails considering cultivation strategies that are both productive and capable of sustaining efficient levels of production over extended periods.

The immediate response to this problem has often been characterised by impassioned calls for increased food production. However, the feasibility of such an endeavour has also been met with considerable scepticism. Two key concerns are particularly significant. Firstly, there is the practical challenge of attempting to increase production when resources are inadequate to support, and more crucially, to sustain such levels of cultivation. Secondly, the moral dilemma arises regarding whether humanity can justify the cultivation of every available square meter of fertile land. This tension has created conflict between human needs and nature, as well as between urban and rural communities. The contentious issue is whether cities possess the moral authority to demand and exploit resources from other ecosystems, not only to ensure their survival but also to facilitate growth. It is therefore essential to reassess the viability of city dwellers continuing to pursue their anthropocentric lifestyles, in a world of ever-diminishing resources and a changing climate.

The right of other species to exist in their natural habitats, free from human intrusion, invasion, or threat, must be acknowledged. Addressing this considerate position suggests that forests and virgin land can no longer be cleared for agriculture, nor resources belonging to other ecosystems be exploited to sustain growing urban demands. Acknowledging this responsibility entails the need to explore strategies that enable urban life to thrive within its own defined limitations. Addressing food demand increases through cultivation should therefore be pursued within the boundaries and domain of the urban environment (Gunawardena, 2008).

1.1.1 A history of cultivation and habitation

Although the notion of 'the city as a farm' might appear fanciful to the twenty-first century urban dweller, the coexistence of cultivation and habitation is not an unfamiliar undertaking. As humanity transitioned from the hunter-gatherer existence to that of the farmer, cultivation became inherently intertwined with practices and rituals of dwelling. This shift compelled humans to abandon their nomadic lifestyle, 'settle', and establish the origins of civilisation. During this agricultural age, human order was inextricably linked with the natural order. Villages were located where cultivation was feasible, often near sources of irrigation. The successes and failures of such cultivation endeavours determined the fate of these settlements.

As civilisation progressed, it developed functional complexities, systems, and operations that defined human order as unique, and 'heroic' compared to the natural order. Consequently, human order began to be characterised by hierarchies, complexities, and an unyielding desire for control. The triumph of 'control' marked the birth of the perpetual power struggle, and with it, the birth of the city. The urban grid symbolised this division, with sectors, zones, and other functional associations emerging to create the desired efficiency of urban habitation. In pursuit of control, human order gradually distanced itself from the natural order, increasingly seeking to control, systemise, and manipulate it for its benefit. As a result, cultivation was segregated from the city, and land was designated elsewhere solely to meet urban food demands. The rural areas became subservient to the urban, supplying resources often to their own detriment. Cultivation was eventually excluded from the unforgiving urban environment altogether, with its land deemed more appropriate for other city functions. The power struggles of the city eventually rendered cultivation in the city, an entirely futile endeavour.

The fundamental conflict of a cultivation agenda in a modern urban setting lies in its inherent need to flourish in an environment that no longer values the natural order. Plants require nutritious soil, unobstructed sunlight, fresh water, and a clean atmosphere to flourish. Modern cities, regardless of their form and operation, consistently fail to provide these necessities. The modern urban state, much like the nature of power and control, is also always in flux, adapting to prevailing interests and physically reorganising itself constantly. A plot of land with adequate sunlight one day, might thus be overshadowed by a building the next year. Sustaining a natural order within a modern urban setting therefore holds limited promise.

City planning endeavours typically implement exclusion policies to safeguard certain functions. Urban agriculture has struggled to be considered by such policies, as prevailing market forces often present arguments for alternative uses with higher economic return. Here again, the urban power struggles marginalise cultivation as an unrealistic urban function. The city operates under the misconception that rural areas will forever supply produce and energy. Urban dwellers as a result have become detached from their impact on rural ecologies, often fostering the illusion that their current state of existence is indefinitely sustainable. As Professor Beddington warned, a crisis is looming, with need to dispel such delusions and prepare for future challenges (McGourty, 2009). Strategies must therefore be developed and implemented, with cultivation needing to renew its association with habitation practices.

1.1.2 Argument for urban cultivation

As Professor Beddington highlighted in the referenced article, urban cultivation strategies are progressively becoming a necessity to address increasing demands (McGourty, 2009). He contended that these strategies had to transcend token gestures, aiming for operational efficiency and productivity. Urban cultivation therefore needs to be addressed through both long-term urban design initiatives and decisive socio-economic policies.

In 2005, Architect Andre Viljoen presented a thesis titled *'CPUs - Continuous Productive Urban Landscapes'* (Viljoen, 2005), which outlined several strategies advocating urban cultivation as a viable endeavour. Viljoen argued for viewing cities as productive spaces akin to rural areas. He affirmed with conviction that 'our cities should be farms' and promoted the creation of networks of green spaces throughout the city (using London as a case study) connected by cycle paths and walkways, combining urban agriculture, recreation, and various other uses. Viljoen's argument was deeply rooted in concepts of embodied energy and 'food miles', as well as 'Permaculture', an approach to designing human settlements and perennial agricultural systems that mimic natural ecological relationships.

Viljoen also supported his thesis with compelling historical justifications of urban agriculture in the United Kingdom, presenting historical images of Clapham Common used for allotments, and people growing food on rooftops during World War Two. He argued that the United Kingdom had a rich history of urban agriculture, highlighted by the fact that during the War years, 10% of the national diet had come from allotments and gardens. The garden path, vegetable patch, backyard shed, and greenhouse were therefore familiar features of domestic cultivation. In modern times however, the hectic and transient nature of urban life had led city dwellers to abandon such activities in favour of convenience. Time and space were perceived as scarce, and with all demand easily met by local supermarkets, there seemed little need for self-cultivation efforts. As a result, children had begun to believe that an apple without a branded sticker was not truly a 'good' apple. Consumer convenience had thus exacerbated the divide between cultivation and habitation, leading to a drastic decline in domestic cultivation engagement.

1.1.3 Technology as means of reconciliation

The survival of an urban cultivation agenda is primarily at odds with urban life because it adheres to a natural order of things distinctly different from the order of the city. The question that arises is whether an urban cultivation agenda always needs to be at odds with the urban order. If control and power define the order of the city, what prevents the pursuit of a cultivation agenda that collaborated, rather than conflicted with such ideals? This approach to conforming the natural order to human constructs is by no means novel. Humanity had engaged in such attempts to manipulate the natural order for its benefit since the dawn of consciousness. Early humans developed tools for more efficient hunting and utilised animal fur for warmth and comfort. Such ingenuity provided opportunities for a better existence, aiding the continual search for a higher state of consciousness. This ingenuity is what is described today as 'technology'. Technology encompasses human usage and knowledge of tools and crafts, affecting the ability to better adapt and eventually control their environment (Basalla, 1988). It is crucial to remember that technology is merely a means to deliver an essence that is desired; technology itself is not an end and always serves a purpose.

If technology is utilised to provide comfortable habitation, the question is whether it could be used to reinitiate the association between cultivation and habitation. Could technology serve to deliver an urban cultivation agenda by reconciling the natural order to serve its purpose within the city's order? The affirmative answer to this question is not a novel concept, and was referred to in technical terminology as the philosophy of ‘closed loop cultivation’, dating back to Greek philosopher Theophrastus’ experiments (372-287 BC). This philosophy manipulated the natural order of growing things to conform to the humanist virtues of power and control. Natural urges were thus tamed by technology (human ingenuity), to deliver causal results that served humanity. Technology therefore reconciled natural instincts to address the challenging complexities and qualities unique to human order (Theophrastus, 1992).

In modern architectural discourse however, technology had repeatedly been misappropriated as an ‘end’, with the essence of existence predetermined and prescribed. This misappropriation began with the superficial acknowledgement of industrialisation. The first mechanised age fostered an attitude that declared technological means not as an actual 'means', but as the 'end' all civilisations must aspire to achieve. This utopian ideal was perpetuated by the development of mechanised aesthetics, as Constructivists, Suprematists, Functionalists, and Futurists weaponised technology to attack conformity, and what they perceived as the archaic order of civilisation. Although such early twentieth century representations of the technological utopia began to wither amidst practical challenges, the post-WWII era reestablished its relevance amidst the belief that it was technology that had liberated the West from war, famine, pestilence, and political tyranny. The 1960s ignited new enthusiasm as theoretical groups like Archigram re-armed with technological constructs, urged for the creation of post-War ‘techno-utopias’. They explored consumerism, advanced communications, and transient occupation, marketing the technological construct and aesthetic as the promising future modern habitation should achieve (Cook, 1991). The 'heroic structure' became emblematic of their representations, with lightweight solutions dominating their techno-utopian imagery. This techno-optimism was somewhat short-lived, as critiquing theoretical groups like Superstudio questioned the techno-utopian endeavour and its obsession with consumer capitalism (Lang & Menking, 2003). Implementation of such representations also never materialised as both market forces and the upper-middle-class self-righteousness of the English academia, remained unconvinced. The latter was exemplified by Michael Webb's graduating project, 'The Sin Centre', which was failed by English academia's archaic sensibilities (Spiller, 2006). The oil crises of the 1970s ultimately condemned the techno-utopia to obscurity, with architectural schools rejecting its 'techno-aesthetic'.

Although the aspirations of the technological utopia ultimately proved insubstantial, this does not negate the theoretical and philosophical challenges that Archigram and other contemporaneous groups sought to articulate. It must again be emphasised that technology serves as a means to achieve an underlying essence, rather than constituting an end in itself. This fundamental principle was overlooked by resolute critics who, upon encountering technological elements, hastily dismissed such projects as mere manifestations of 1960s 'high-techery'. Such prejudice arises from a misinterpretation of a project's external manifestation (its aesthetic) and its intrinsic purpose (its intended objective). Anti-technology perspectives invariably fixated on and judged the former while disregarding the latter. The presence of 'heroic structures' particularly triggers and provokes prejudicial responses. Such structures were described as 'heroic' simply because Peter Cook assigned them such a description (Cook, 1991). Regardless of this designation their purpose was to represent the pragmatic honesty of architecture that Vitruvius described as *stabilitas*. Structural configurations that achieved stability are integral to the composition of a building and should not be mistakenly perceived as entirely emblematic of superficial aesthetics. A shallow approach to architectural critique led to the mischaracterisation of the 'heroic' as 'villainous', opportunistically manipulating aesthetic perceptions to determine what merited the classification as worthy architecture.

The recognition of technology and the application of the philosophy of 'closed loop cultivation' were therefore confronted with the considerable challenge of overcoming entrenched prejudice in architectural discourse and practice. Given the association of technology with perceived failures of the 1960s, criticism was often shaped by the context of that era. From its inception, this project was as a result compelled to surmount significant obstacles, pursued, as Professor Beddington had contended, precisely because technological innovation presented the most pragmatic and sustainable means of advancing an urban cultivation agenda. It must be unequivocally stated that the project does not seek to replicate or glorify the high-tech aesthetic of the 1960s. Rather, technology was employed in a pragmatic manner to address an issue of profound significance to all.

1.1.4 Presenting a macro response

Professor Beddington, in his aforementioned warnings, had emphasised that cultivation strategies should not be considered in isolation (McGourty, 2009). A fragmented approach to such a complex issue offers little scope for long-term strategic viability. Cultivation therefore must be addressed at a macro scale, with overarching initiatives that would eventually inform and shape its fundamental building blocks, represented by individual dwelling units. The macro-scale gesture needs to establish a meaningful relationship with finer details, which in turn, would influence the practices and rituals of contemporary habitation (Gunawardena, 2008).

Andre Viljoen's concept of 'CPULs' effectively demonstrated such macro-to-micro relationships through his extensive proposals for creating interconnected networks of green spaces across the urban fabric (with London as a case study), linked by cycle paths and pedestrian walkways, combining urban agriculture, recreation, and various ancillary uses (Viljoen, 2005). Viljoen's research extensively examined strategies involving green walkways, wedges, belts, and other urban green infrastructure interventions. Therefore, merely reiterating these strategies within this design thesis would provide little additional value. Instead, this project seeks to address the need for macro-scale urban cultivation strategies through an alternative and frequently misunderstood approach: the 'green mega-structure'.

A more detailed dialectical critique of the mega-structure will be presented later in the thesis; however, it is essential to first outline the rationale for adopting such a strategy. The mega-structural system was pursued here primarily for its unapologetic embrace of 'bigness', the ultimate articulation of the macro condition. Additionally, it was considered for the socio-economic and political implications inherent in large-scale urban strategies. The gradual adoption of urban cultivation through democratic persuasion, rather than its enforcement via authoritarian policy, was deemed a fundamental priority of this project. The mega-structure was thus employed as a vehicle to convey a radical reimagining of habitation and cultivation, while acknowledging the socio-economic intricacies of both present and future urban power dynamics.

Much like technological advancements, mega-structural endeavours have often been vilified within architectural discourse as acts of urban brutality. In a manner akin to prejudices against high-tech approaches, scepticism surrounding mega-structures has its roots in the failures and disillusionments of the 1960s. The mega-structure became emblematic of that era and was frequently judged on its outward manifestations (aesthetic), rather than its intrinsic purpose (what it sought to achieve). This project from its inception therefore faced yet another formidable challenge, pursued not as a nostalgic homage to past architectural experiments, but rather as an inadequately explored strategy to address contemporary urban concerns.

1.1.5 Research focus

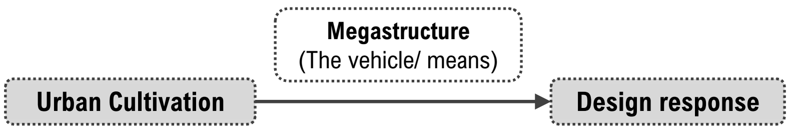
This thesis, with a clear and unequivocal focus, seeks to examine the challenges inherent in pursuing an urban cultivation agenda within Redcliffe. Beyond this scope, it does not seek to interrogate the broader necessity of urban cultivation strategies, as extensive empirical evidence, such as that presented by Professor Beddington and Andre Viljoen, strongly affirmed their importance.

Furthermore, this thesis deliberately refrained from simply reiterating the strategies already advanced by Andre Viljoen. Instead, it seeks to offer an additional and distinct contribution to the existing body of urban cultivation strategies.

Urban Cultivation Strategies = [Green wedges], [Green belts], [Green Walkways/paths/ and bands] ... + **[GREEN MEGA-STRUCTURE]**

The thesis in its precise focus, examines the complexities of establishing a viable model of urban cultivation through the implementation of a green mega-structural system.

Diagram of research focus



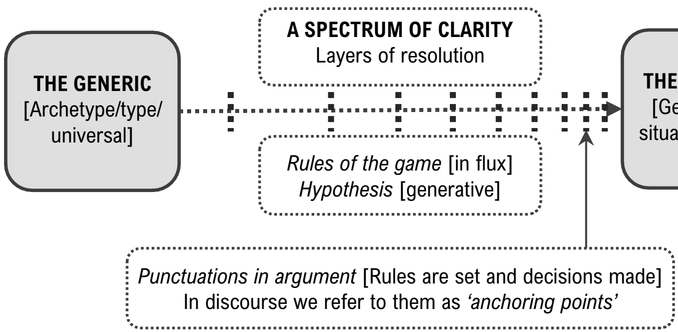
1.1.6 Workings of a polemic

This thesis was developed with the firm conviction that it constituted a work of social scientific inquiry. Accordingly, it did not position itself as a positivist endeavour aimed at validating a predetermined hypothesis. Instead through its progression and development, the research enterprise seeks to pose critical questions and deliberately function as a 'hypothesis-generating' investigation. As a result, the narrative experiences multiple iterations and layers of refinement, culminating in a project that advances a thought-provoking and polemical argument. Given the inherent complexity of a polemical approach, its true intent requires explicit clarification, as it could be frequently misunderstood, leading to premature dismissal.

A polemical argument operates on the premise of instigating change by presenting an agenda that elicits diverse responses from various stakeholders. These responses in turn contribute to the generation of new hypotheses, refining the agenda to accommodate the practical challenges of real-world implementation. The finalised project therefore does not purport to offer a definitive solution but instead represents a hypothesis-generating body of work. The points it raises constitute both theoretical and practical inquiries that must be addressed to inform the future trajectory of urbanism and architecture. As a polemical project it adopts the role of the devil's advocate, interrogating established norms to discern which fundamental aspects of the past and present merit preservation and continued relevance.

A polemical project is meant to be a disruptor. They critically address future habitation possibilities by engaging with trend forecasts to formulate responses based on likely scenarios. Conforming solely to present values would render any thesis redundant on arrival, while polemical arguments evade this by rigorously interrogating both historical and contemporary frameworks to project potentials. By questioning the past and present, such projects ensure relevance to evolving urban and architectural discourses. Its purpose however is not merely to provoke, but to facilitate meaningful discourse on emerging practices. Addressing the future necessitates inquiry beyond immediate acceptability, fostering vigorous debate that drives urban evolution. In this way, polemical projects serve as catalysts for transformative change in architecture and urbanism.

Presenting an argument diagram



A key consideration throughout this project was the preservation of the archetypal essence of habitation and cultivation, while developing a manifestation responsive to the evolving needs of an urban future. While the objective remained unchanged, the methods had to adapt to address new challenges. This required moving beyond superficial interpretations of 'context' and 'sensitivity'. True contextuality transcends material, style, and scale, instead representing meaningful engagement with the environment, influenced by philosophical, economic, political, and pragmatic dimensions.

The macro-to-micro relationship in urban design operates between the generic and the specific. An urban agenda must acknowledge universal principles of habitation, situating its equilibrium accordingly. In this thesis, the mega-structural system represents this condition, aspiring to be as archetypal as the site and urban situation permit. This approach ensures adaptability, allowing various stakeholders to refine its generic attributes to meet specific needs. The mega-structure functions as a dynamic platform, providing foundational discourse, while enabling independent narratives to emerge.

At its core, this project explores how urban interventions shape authorship. Instead of imposing rigid frameworks, it promotes an open-ended system that accommodates evolving perspectives. By questioning established norms, this thesis positions itself within a broader discourse that critically examines the intersection of architectural and urban evolution, ensuring that future habitation strategies remain flexible, responsive, and meaningfully engaged with their context.

2.0 Understanding the site context

2.1 Historical background

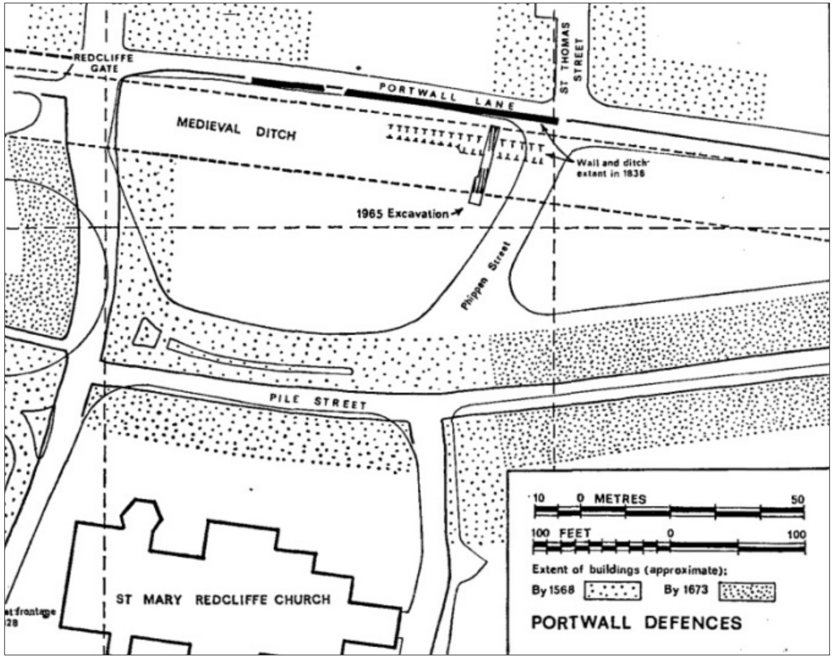


Plate 1. Archaeological survey.

The founding of the settlement at Redcliffe is attributed to Robert, the Earl of Gloucester, in the early twelfth century. This settlement maintained its independence from the jurisdiction of the city of Bristol until its incorporation into the newly formed County of Bristol in 1373. The Earl had carefully planned the western half of Redcliffe, delineating long, narrow housing plots of uniform width along the main streets. The construction of new parish churches, including St. Thomas and St. Mary Redcliffe, was undertaken to accommodate the spiritual needs of its growing population (Ison, 1952).

2.1.1 Legacy of a city wall

In the mid-thirteenth century, a new town wall known as the Portwall was constructed to enclose the suburb, including stone gates across Temple Street and Redcliffe Street. Portwall Lane, which runs parallel to Redcliffe Way, originated as a radial access route along the inside of this wall. Several archaeological surveys had been conducted concerning new building work on the northern front of Portwall Lane. Generally, these surveys had unearthed fragments of medieval pottery, but nothing else of value had been discovered. Additionally, little physical evidence of the medieval ditch that once lay along this wall's course, is currently evident (Ison, 1952).

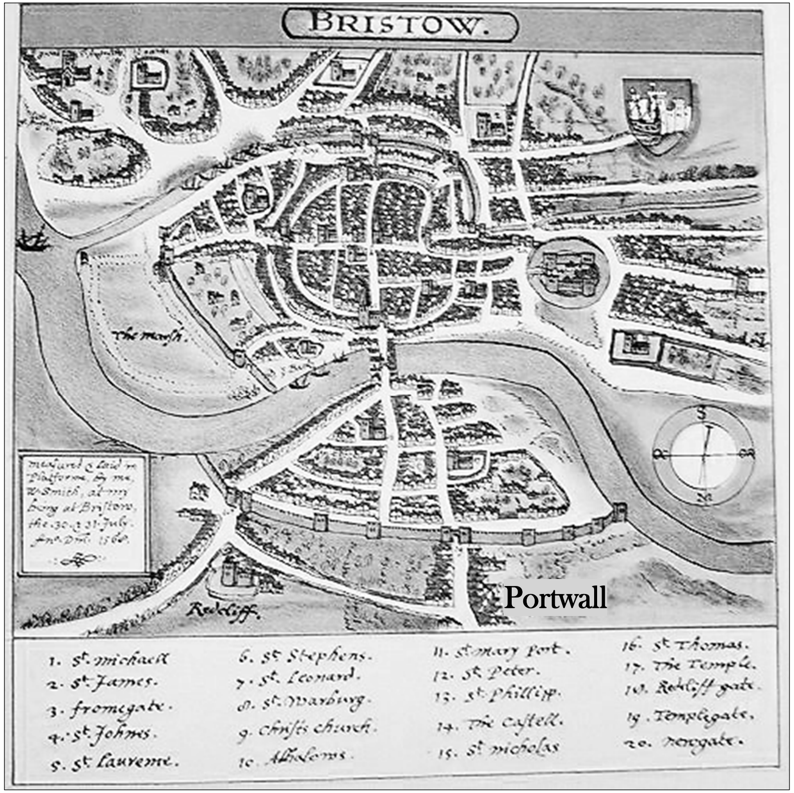


Plate 2. William Smith's bird's-eye view of Bristol (1568), showing the Redcliffe Portwall and two gates built across Temple and Redcliffe Streets.

Notwithstanding the lack of evidence thus far, the proposal of this thesis would still necessitate a detailed archaeological survey to be conducted in collaboration with the County Archaeological Department. This is essential to ensure that the proposed mega-structural system does not displace any valued historical footprints or artefacts.

2.1.2 Contributions to the collective psyche

The city wall of any settlement was a significant presence in the organisation and evolution of its socioeconomic struggles. The remnants and traces to its presence connects the modern city's experience to such evolutionary milestones. In dedication to this, the evolving urban grainps of cities have sought to preserve hints of it in some form. In Bristol, the bowed course of St. Nicholas Street serves as this reminder of its first city wall. Similarly, Portwall Lane stands as a reminder of the city’s second wall, the Portwall (Ison, 1952).

The city wall as a construction conforms to the archetype of a mega-structure. Indeed, it could be regarded as the first mega-structural intervention used in traditional settlement planning and construction. As a significant infrastructural endeavour, it was intended as a defence barrier foremost. This evolved to encompass a multitude of other functions in times of peace to become a complex entity. In most instances, this city wall integrated the functions of day-to-day living and even trade. It gradually transformed into a symbolic representation of an inhabited threshold between the civilised inner world of safety, and the uncivilised outer world of danger beyond.

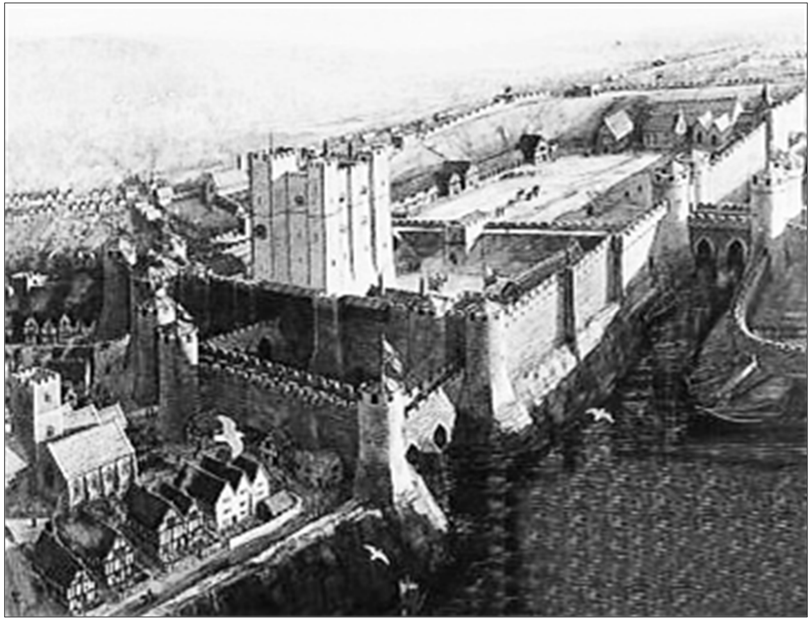


Plate 3. Chris Molan's depiction of Bristol Castle with its great walls in their heyday, around 1300 (Molan, 2001).

Besides the city wall, significant contribution to the collective of Redcliffe was presented by the thirteenth-century parish church of St. Mary Redcliffe (Britton, 1813). This church's axes established the *axis mundi* for Redcliffe. Spiritual unity was thus established by these axes, which presented the datum for all future building events.

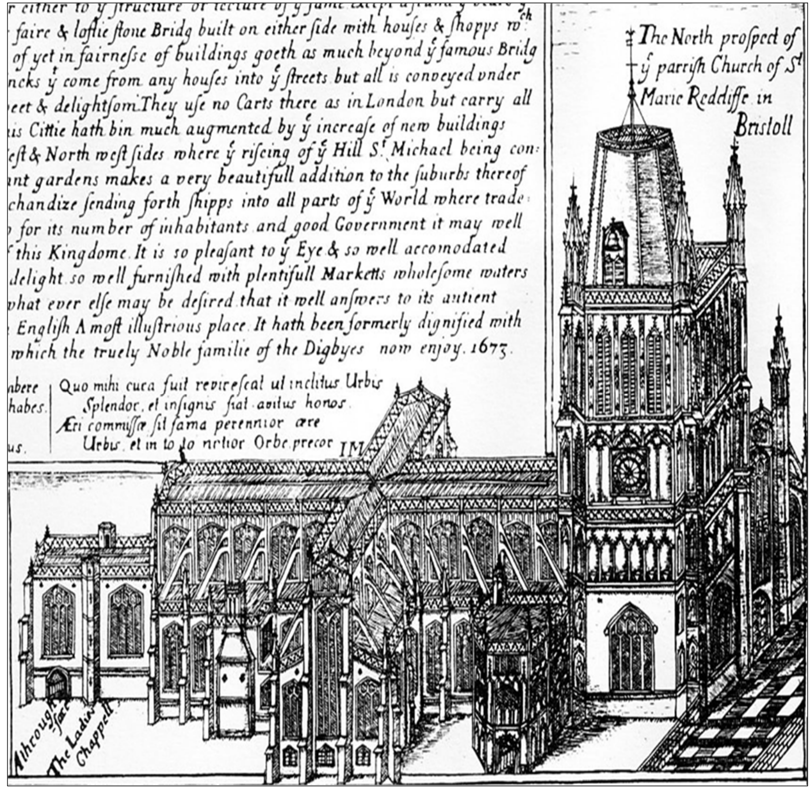


Plate 4. In 1673, James Millerd published the first map of Bristol, in which he highlighted several significant buildings of the city. Above is his representation of St. Mary Redcliffe with its incomplete spire (Millerd, 1673).

In a post-Nietzschean era where reverence for the mystical has diminished, the commanding presence of the church persists. However, its symbolic association has transformed from representing the divine, to expressing a more nebulous sense of spirituality. The pursuit of this spirituality continues with most of the city's inhabitants, irrespective of their original faithful affiliations. In this context, St. Mary Redcliffe has retained its spiritual significance as a psychic symbol. Its presence in the city thus commands attention, and in respect of this enduring attention, it should not be eclipsed.

Any urban regeneration agenda for Redcliffe must achieve its objectives with due regard for the original presence of both the city wall and St. Mary Redcliffe. However, this idea of 'regard' should not be misconstrued as a mere adherence to the scale, form, or aesthetics of these historical structures. In this context, 'regard' signifies a deeper understanding and recognition of the contributions these historical markers have made to Bristol's collective psyche.

Meaningless engagement with history results only in the preservation of the past. It must be understood that cities are not museums; but dynamic entities rooting from their founding values, shaped by present-day power struggles, and continuously forging a path towards a prosperous and lasting future. The histories of cities hold significance because they are repositories of these collective truths, offering to all invaluable lessons of triumph and misfortune. It is these lessons, rather than manifestations of the past, that must be respected.

2.1.3 Pastoral heritage

James Millerd's maps and other historical cartographies show that St. Mary Redcliffe was once surrounded by a pastoral landscape (Britton, 1813). However, with industrial expansion (notably in the glassworks area) and population growth, this rural setting was transformed. By 1885, the pastoral environment had largely disappeared, leaving only the preserved greenery of the churchyard (Ison, 1952).

Plate 5. The building of the Portwall and its impact on an existing landscape (source: St Mary Redcliffe Conservation Plan, 2003).

Plate 6 Plate 29

2.1.4 Pastoral imagery

Plate 7. Plate L41

Plate 8. Portwall Lane, view towards St Mary Redcliffe.

Plate 9. Preserved view from Temple Gate (SPD 03).

2.2 Existing urban situation

Redcliffe is a district of the port city of Bristol, located southeast of the city centre. It is bordered by the loop of the Floating Harbour to the west, north, and east, the New Cut of the River Avon to the south, and Temple Way and Temple Gate to the southeast. Most of Redcliffe lies within the Lawrence Hill City Ward, while the westernmost section, including the cliffs and hill from which the area derives its name, is part of the Cabot Ward.

The district takes its name from the red sandstone cliffs that line the southern side of the Floating Harbour, behind Phoenix Wharf and Redcliffe Wharf. These cliffs are perforated with tunnels, originally constructed for sand extraction to support the local glassmaking industry, and later served as storerooms for port goods. St. Mary Redcliffe is the parish church, and is one of Bristol's notable churches. Designed in the Perpendicular Gothic style, and constructed between 1185-72, its spire reaches a height of 84 metres (Ison, 1952).

2.2.1 Transport and access

Redcliffe Way was constructed as a dual carriageway between 1939 and 1940 to form part of an inner-city ring road, directing vehicular traffic diagonally across Queen Square (1937), towards the town centre. As part of this ring road, a flyover was also built on Redcliffe Way, though it was demolished in the late 1980s.

Following the removal of the diagonal crossing through Queen Square in 2000, and its subsequent restoration, the significance of Redcliffe Way for vehicular traffic had diminished, resulting in much of its lanes becoming underutilised and redundant. Informed by traffic flow studies, the Redcliffe Futures Masterplan (Bristol City Council, 2002), has therefore proposed a significant downgrading of Redcliffe Way. This thesis concurs with this Masterplan proposal.

2.2.2 Pedestrian flow

Portwall Lane, which runs parallel to Redcliffe Way, has been designated by Bristol City Council as a key section of the 'Brunel Mile'. The aim of the Brunel Mile is to establish a pedestrian route across the city, connecting Brunel's legacy at Temple Meads Station and the SS Great Britain, through new public spaces and squares.

The development of the Brunel Mile is divided into three sections:

1. Millennium Square, Pero's Bridge, and Queen Square;
2. Portwall Section; and
3. The Harbourside: Western Promenade, Harbour inlet, and cross Harbour Ferry.

The Portwall section of the Brunel Mile development was launched in January 2008. It is the second section to be completed and runs from Freshford House to Redcliffe Way (island site crossing), passing through the Redcliffe neighbourhood.

Picture plate 42

Plate 10. Brunel Mile proposal.

2.3 Proposed urban strategies

Plate 11. Temple Quarter Development with its three key zones.

2.3.1 Redcliffe Futures Masterplan

Supplementary Planning Document 03 outlines the vision for Redcliffe as *"a sustainable neighbourhood of compact, mixed-use development that is human scale, accessible to all, and respectful of the area's history and character."* (Bristol City Council, 2006).

This vision is supported by six objectives, which detail the guiding principles for future development (Bristol City Council, 2002):

1. Integration and balance of economic, social, environmental, transport, and townscape factors.
2. Provision for transport and parking that positively contributes to Redcliffe, prioritising local movement, particularly on foot and by bicycle.
3. A high-quality townscape that builds on the distinctiveness and character of Redcliffe, considering historical assets and the relationship to the harbour.
4. A network of high-quality public streets and spaces that maximises connections within and beyond Redcliffe.
5. The development of a vibrant mixed-use economy, with a focus on expanding the local economy.
6. The development of a range of community facilities.

2.3.2 Critique of the Redcliffe Futures vision

The vision for Redcliffe, as presented in SPD 03 (2006), largely focuses on increasing the density of development within the 'island' by introducing a mixed range of uses. However, in identifying appropriate townscape strategies, it remains cautious and refrains from challenging or re-evaluating existing urban concerns.

At the centre of this 'high density, mixed-use' vision is the potential for generating greater economic advantage for the district. The Masterplan identifies Redcliffe Way as an underutilised asset, with more than £400 million worth of prime land currently tied up in an underused road. Consequently, the plan proposes to unlock this value through the introduction of a dense urban block along Redcliffe Way, while narrowing flow and limiting its vehicular traffic (Bristol City Council, 2002; 2006).

While the thesis proposal acknowledges the downgrading of Redcliffe Way, it views the vision as little more than a continuation of the status quo. It does not engage with the pressing urban issues of today, opting instead for a cautious urban planning approach, influenced by traditional models from cities such as Rome.

The significant opportunity for Redcliffe lies in the redundant road and surrounding vacant land. While adding mixed-use buildings may release £400 million in the short term, it would offer limited long-term benefits to Bristol as a whole. This is further exacerbated by the current economic climate, which does not see long-term value generation from building offices and luxury apartments. Once urban land is developed, it is challenging to repurpose. With vacant land available without the need for demolition or clearance, the opportunity should therefore be seized to create a strategic urban contribution that benefits all of Bristol's inhabitants.

This design thesis adopts a critical perspective on the conservative approach presented in the Redcliffe Futures vision. It advocates instead for the conversion of the vacant site on Redcliffe Way into an urban cultivation park. This proposal addresses the pressing need for cultivation strategies within the city, and offers a more productive and sustainable utilisation of the land (Gunawardena, 2008).

2.3.3 LRT route and access

Over the past 15 years, Bristol City Council has explored the feasibility of reintroducing a tram system, inspired by the success of similar initiatives in northern cities such as Nottingham. As part of this, the 2003 Local Development Plan has preserved a route through Redcliffe Way for a light rail transport service (LRT). This line aims to connect central Bristol with Parkway Station in the north, via Redcliffe Way and Temple Meads Station. The route forms part of a broader strategic objective to reinforce central Bristol's economic competitiveness, particularly in contrast to Cribbs Causeway's established status as an out-of-town retail and commercial hub. The successful completion of this transport link is therefore crucial for the economic prosperity of Bristol's town centre, especially in relation to the newly developed Cabot Circus (completed in 2008).

Three independent studies, with the principal one being the Atkins Report, had been conducted concerning the proposed transport line. These studies have endorsed the strategic decisions under consideration and recognised the route through Redcliffe Way as both viable and appropriate. In terms of planning policy, the incorporation of a rapid transit line through Redcliffe Way is therefore not so much a question of 'if', but rather 'when' it should be implemented.

The proposal of a Light Rail Transit (LRT) system has been significantly inspired by several successful European models (e.g., Barcelona, Plate 12), as highlighted by the Atkins Report. In general, LRT systems are more sustainable than any other form of mass transit, offering low operating costs that result in more affordable fares. Additionally, their tracks can be seamlessly integrated into urban roads without causing significant disruption. The primary disadvantage of such systems is the substantial capital investment required. The estimated cost of the proposed line is £150 million, and securing this necessary funding has been a major concern for Bristol City Council. Consequently, the project has been temporarily postponed, following the recommendation of the Department of Transport (DfT).

This thesis acknowledges the LRT proposal as a positive initiative for Redcliffe, and proposes that it be introduced at ground level for a third of Redcliffe Way. Beyond this point, the line should be elevated to pass over Temple Gate and be connected to a new Temple Meads transport exchange, thereby ensuring that it does not interfere with the traffic flow of the proposed ring road at Temple Gate.

Plate 12. Barcelona's tram network together with the city's Metro service delivers an efficient public transport service.

2.4 Site opportunity

The Redcliffe Futures Masterplan has also recognised the significance of the proposed LRT line, and its designated route as a significant element in the regeneration of the Redcliffe area (Bristol City Council, 2002). Considering this, the Masterplan presents two potential routes: the preserved route, and an alternative route (Plate 13).

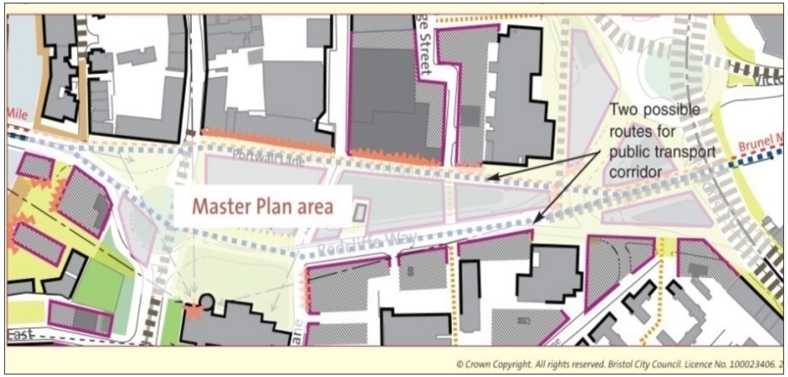


Plate 13. Extents of the Redcliffe Futures Masterplan area of Redcliffe Way.

The strategic policy underpinning the LRT proposal makes it an inexorable consideration for Redcliffe. The opportunity for Redcliffe lies in leveraging this line as a significant infrastructural asset. This thesis adopts an analogous perspective, recognising the potential of the line to serve as a foundational/trigger infrastructure asset.

The proposed LRT route (see Plate 14), alongside the extensive and vacant expanse of the Redcliffe Way site, presents a unique opportunity to explore an urban development strategy that is both bold and ambitiously forward-thinking. It is essential to emphasise that it is ambition that shapes the future; and thus is the driving force behind progress. When such opportunities arise, as they have in Redcliffe, they must be seized and utilised to craft a vision that is both progressive and attuned to the challenges of today, as well as the future.

2.4.1 Planning approval strategy

Given the scale and strategic nature of the proposed project, it would be most effective to seek planning approval for the entire mega-structural system initially through an Outline Planning Application. Following this, the application for the proposed 'Institute of Urban Cultivation' could be submitted as a separate Detailed Application, based on the outline approval granted for the mega-structural system. In addition to the Institute of Urban Cultivation, other components of the system, such as 'algae decks' and 'food towers', may be submitted as Reserved Matters, contingent upon the outline approval of the mega-structural system (Gunawardena, 2008).

The standard 40-meter bay of the proposed mega-structural system allows the larger enterprise to be divided into 'bay segments'. Each of these segments can be treated as separate applications, with each accompanied by a specific Business Plan (refer to Chapter 5.0).

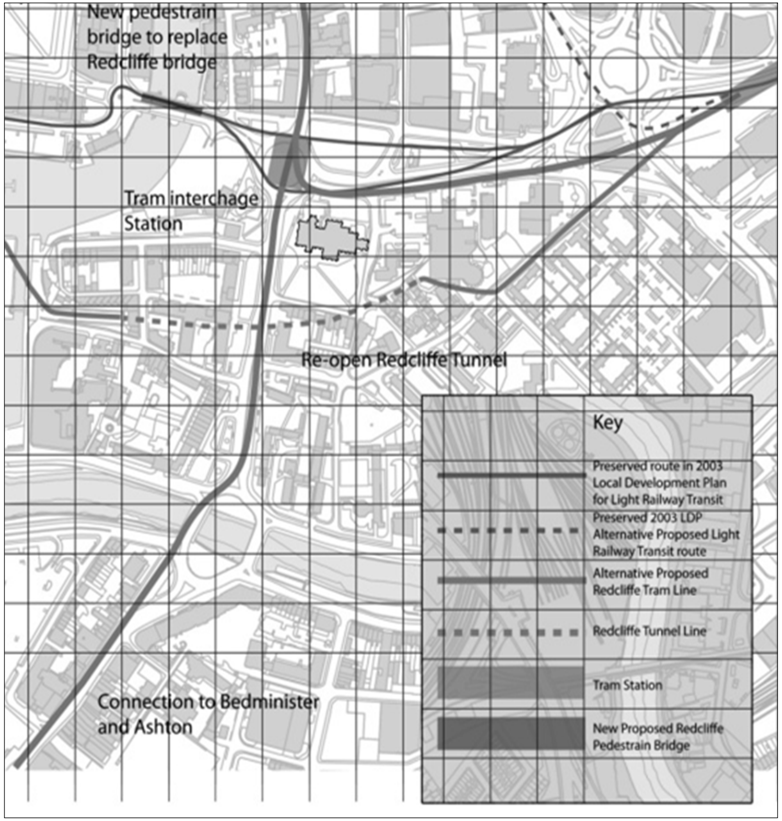


Plate 14. Proposals map with proposed and alternative LRT routes, (© Kanchane Gunawardena and Nathan Bloomfield).

2.5 Local environment

2.5.1 Local climate

To synthesise an efficient approach to urban cultivation, it is necessary to acquire a comprehensive understanding of local climatic conditions. This knowledge will allow for the effective determination of viable passive or active solutions. Furthermore, it would enable the identification of multifunctional solutions that could be adopted to utilise the mega-structural system to its fullest potential.

Table 1. Weather averages for Bristol, England, United Kingdom.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average high °C (°F)	7 (45)	8 (46)	11 (52)	15 (59)	18 (64)	21 (70)	23 (73)	23 (73)	20 (68)	15 (59)	11 (51)	8 (46)	15 (59)
Average low °C (°F)	3 (37)	2 (36)	4 (40)	7 (45)	9 (48)	12 (54)	14 (58)	14 (57)	12 (53)	9 (48)	5 (41)	3 (37)	8 (46)
Precipitation mm (inches)	97.7 (3.85)	53.8 (2.12)	85.9 (3.38)	65.0 (2.56)	92.5 (3.64)	70.6 (2.78)	79.8 (3.14)	56.6 (2.23)	64.5 (2.54)	113.3 (4.46)	118.6 (4.67)	117.0 (4.61)	1,015.3 (39.97)

Source: Weatherbase, 03/08/2007; & Met Office, Yeovilton, 03/08/2007.

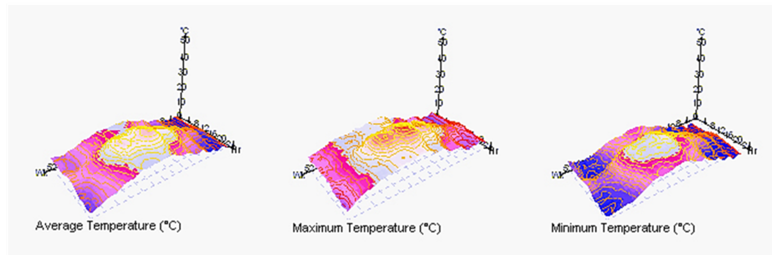


Plate 15. Annual Temperatures for Bristol.

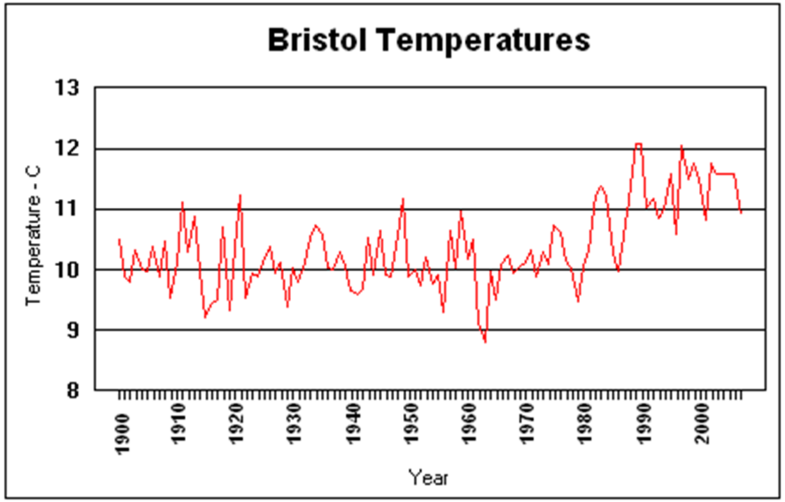


Plate 16. Bristol temperature records from 1900.

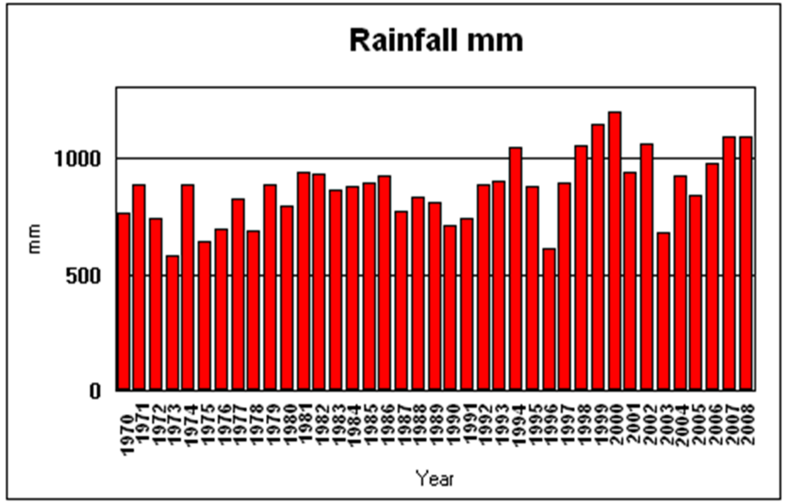


Plate 17. Bristol precipitation records between 1970-2008.

The graph above illustrates average temperatures in Bristol since 1900. As a general trend, it highlights a rise in average temperatures over the past century, coinciding with urban development. The primary effect of this change has been the milder winters experienced, rather than an increase in summer temperatures. This shift has had various environmental and social implications, influencing everything from energy consumption to local ecosystems. The ongoing trend calls for careful urban planning and sustainable practices to mitigate potential negative impacts on the city's growing population.

The above graph represents the total rainfall each year in the Bristol area since 1970. There does not appear to be any clear overall trend, with the past few years showing consistent rainfall figures. Urban rainfall, particularly in relation to localised precipitation, often has lower pH levels, indicating increased acidity due to pollutants. This can be detrimental to certain crops, as the acidic rain may affect their health and growth. As a result, harvested rainwater may require treatment, especially if it is to be used in active growing solutions or agricultural systems, to ensure optimal crop production.

Considering the climate data presented above, it is important to emphasise that the climatic conditions in Bristol are not favourable for the cultivation of all food crops. Consequently, only certain varieties can be effectively grown under entirely natural (passive) conditions. A prudent approach would be to cultivate local crops that are well-suited to Bristol's climate in conditions capable of supporting passive growth, such as areas with high solar exposure. For crops less suited to these conditions, active mechanisms may be necessary to sustain viable growth within appropriate active settings.

Active solutions need energy to facilitate and sustain plant growth. The energy consumption and associated carbon emissions of such systems must be accurately evaluated in relation to the crop yields they generate. The emphasis in this context, should be on the 'net gains' or 'net losses' in carbon. Should active growing systems produce yields exceeding typical production levels, the carbon calculations may still validate the viability of this approach. Therefore, active growing must be implemented with a strategy of onsite carbon offsetting in mind. Enhancing the efficiency of offsetting could potentially lead to carbon-negative outputs, thereby rendering the entire system advantageous to the urban ecology and its inhabitants.

Seasonality

Another consideration to emphasise is the seasonal nature of Bristol's temperate climate. Although winter temperatures have become progressively milder over the years, they remain largely hostile for year-round crop cultivation. The summer months continue to offer the most advantageous natural conditions for passive cultivation; while two possibilities are presented for the harsher winter months: to employ active cultivation strategies under controlled conditions, and/or repurpose the mega-structure for alternative functions.

If both possibilities are pursued as is the case in this proposed project, careful consideration must be given to determining which solution provides the most efficient use of resources (active growth has been prioritised here). The ability to switch functions from growing to other uses requires the infrastructure to incorporate a high degree of flexibility. Thus, the seasonality of the climate further underscores the need for the mega-structural system to be designed with multi-functionality in mind, both in terms of its morphology and function.

2.5.2 Appropriate site for cultivation

The historical justification for the selection of the site was outlined in Section 2.1, where its forgotten heritage of cultivation was highlighted. This section now considers the prevailing environmental conditions and their suitability for fostering a renewed interest in urban cultivation along the Redcliffe Way site.

The equation for photosynthesis:

$$CO_2 + 2\,H_2O + \text{photons} \rightarrow (CH_2O)_n + H_2O + O_2$$

Carbon dioxide + water + light energy → carbohydrate + water + oxygen

Photons, or light energy, are a vital component of the photosynthesis process (Lambers, et al., 1998). To facilitate successful cultivation, light energy must be sufficiently available. Incident Photo Active Radiation (PAR) from the sun should be harnessed as much as possible for cultivation, with artificial PAR used only as a last resort to address critical shortfalls, or significantly increase yields.

In its current state, the site presents an excellent opportunity for re-introducing cultivation without requiring demolition or clearance works, thus minimising the adverse environmental impacts of land acquisition. This largely vacant state of Redcliffe Way also means that by default it offers higher levels of solar exposure, making it suitable for implementing passive cultivation strategies.

To ensure optimal levels of incident PAR, the orientation of both the building and the site must be considered. Redcliffe Way is aligned on an east-west axis, enabling the proposed mega-structural system to feature a south-facing facade that fronts the proposed cultivated urban park. This orientation allows for the creation of a vertical cultivation space, unobstructed by contextual shading, and benefiting from extended sunlight exposure hours throughout the day. The south-facing facade provides the ideal environment for maximising solar absorption, thereby enhancing the cultivation potential of the site, and supporting dominant passive cultivation. Thus, Redcliffe Way in its present state stands as an ideal underutilised site for a productive urban cultivation project.

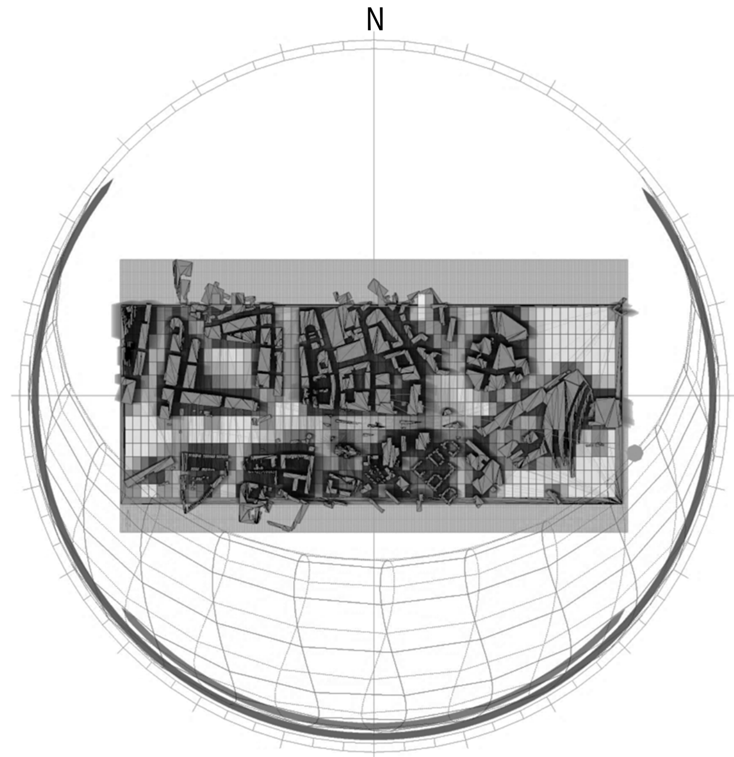


Plate 18. Annual shadow distribution demonstrating the vast and exposed environment of Redcliffe Way.

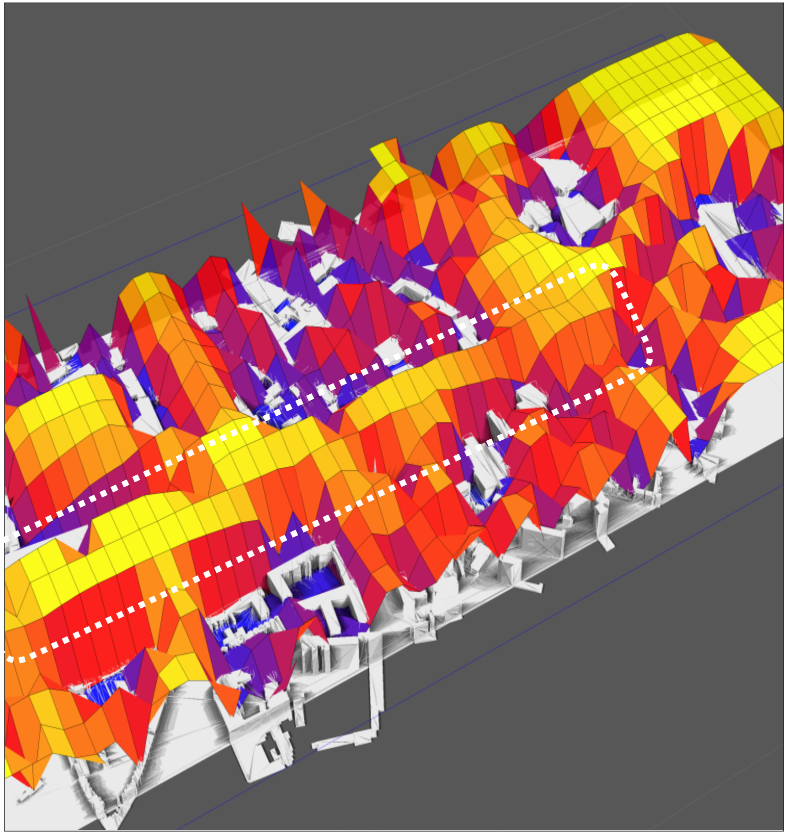


Plate 19. Redcliffe Way, Isolation analysis of average percentage exposure.

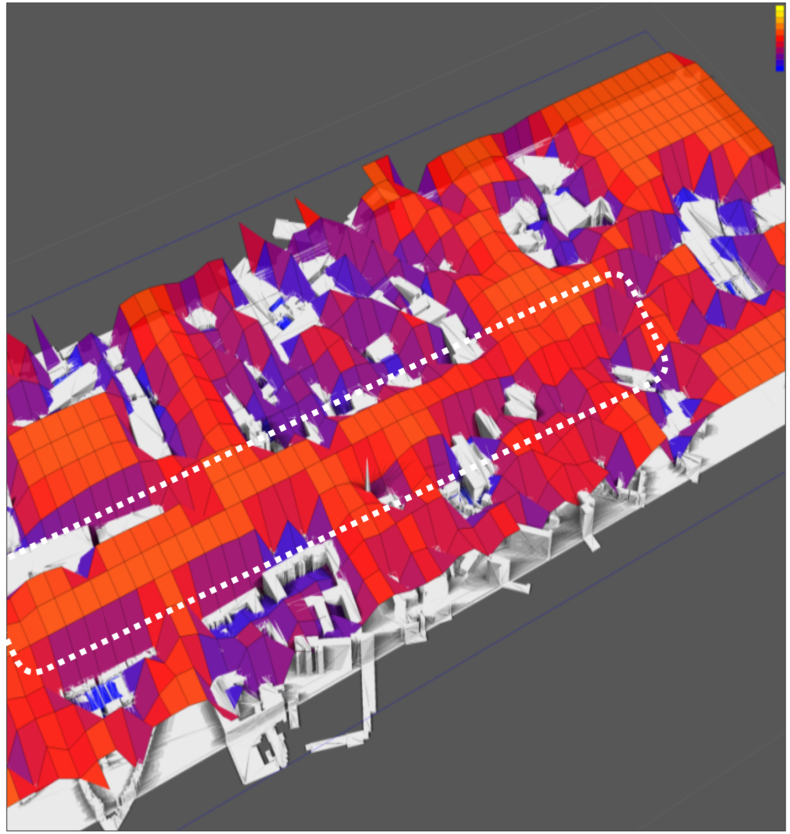


Plate 20. Redcliffe Way, Daily average of Photo Active Radiation (PAR).

3.0 Aspirational brief

3.1 Statement of need

As outlined in the BBC article introduced in Chapter 1.0, Professor John Beddington emphasised that emerging cultivation strategies are increasingly becoming essential to meet the escalating food demands of urban populations. He asserted that such strategies must move beyond symbolic or superficial gestures, instead prioritising scalable efficiency in both operational and productive capacities. Accordingly, urban cultivation should be framed as a long-term urban planning programme, to be realised through integrated socio-economic and environmental policy frameworks (McGourty, 2009).

Furthermore, Professor Beddington underscored the importance of not considering such cultivation strategies in isolation. A fragmented or piecemeal approach offers limited potential for achieving sustained strategic impact. Urban cultivation must instead be conceptualised as an integral component of a broader, macroscale strategy. This necessitates substantial interventions at the urban scale, whose cumulative effects ultimately permeate down to influence the city's fundamental microscale elements; namely, individual dwelling units. any macroscale initiative must therefore maintain a coherent relationship with these microscale units, thereby shaping the everyday practices and rituals that characterise contemporary urban living.

Urban theorist André Viljoen's (2005) concept of Continuous Productive Urban Landscapes (CPUL) exemplifies a strategic approach that addresses macro-to-micro urban relationships through the establishment of interconnected networks of green infrastructure. Using London as a case study, he envisioned cities as productive settlements, where green corridors comprising cycle paths, walkways, and multifunctional landscapes, integrate urban agriculture, recreation, and other civic uses. This model not only sought to mitigate issues such as resource depletion and the environmental costs of energy-intensive food transportation, but also aimed to enhance the urban environment by generating employment, improving microclimates, and contributing to the aesthetic quality of the broader cityscape. Furthermore, he provided a comprehensive account of green infra-structure strategies, including vegetated belts, linear parks, clusters, and wedges. As these strategies are already well-documented and illustrated by his work, reiterating them in this design thesis would offer limited additional insight. Instead, this project explores an alternative, and often underappreciated approach to macro-scale urban cultivation: namely the 'green mega-structure'.

A significant challenge faced by urban cultivation initiatives is the acquisition of uncontaminated vacant land. In contemporary urban environments, securing the necessary land for such endeavours is a challenging and costly task, particularly when demolition and clearance is severely restricted. As a result, horizontal or surface cultivation approaches are often not feasible. This necessitates the consideration of vertically spanning approaches to deliver sufficient coverage to meet the long-term demands of growing urban populations.

The previous chapter's site opportunities discussion highlighted the current exposed and vacant state of Redcliffe Way and its adjoining land. Thus, the search for vacant land or need to create vacant land through demolition and clearance, is not required in this instance. The vacant land opportunity therefore already exists at Redcliffe (subject to decontamination to remove pollutants). This design thesis seizes this opportunity and seeks to further enhance provision by embracing vertical expansion. This is explored here by the strategy best described as a 'green mega-structure', which would aim to nourish and power the population of Redcliffe for many years to come.

For a green and productive mega-structure to succeed, it must not only by design offer multi-functionality and have the capacity for adaptation and expansion, but also present a persuasive and enduring argument for local inhabitants and beyond, that urban cultivation practices are a long-term benefit to the city. Only through increased and dominant participation can such an endeavour address the core concerns highlighted by Professor Beddington.

The purpose of the green mega-structure must therefore be associated with efforts to persuade and educate the wider community of the merits of urban cultivation. The proposed Institute of Urban Cultivation (IUC) is intended to deliver this agenda, while also acting as a gateway building to the green mega-structure, thus ensuring a promising foundation for an initiative that has the long-term strategy to deliver an evolving and expanding urban agricultural system.

3.2 Dialectical thesis for mega-structures

3.2.1 Antithesis for the 'mega'

The prefix 'mega' is derived from the Ancient Greek word *mégas*, which translates to mean 'great' or 'large', i.e., the relative increase in dimensional extents. It is often referred to in the common tongue as 'bigness', with little consideration to its essence. It is indeed a relational concept, defined by an individual's understanding of their Self in relation to the vastness of the environment that this Self is immersed within. The ultimate manifestation of this bigness is the wider natural environment. Bigness is therefore daunting, overwhelming, and if not approached with caution, gives rise to deep anxiety. This anxiety leads to the questioning of their existence and encourages uncertainty, which every individual instinctively resists in their quest to find contentment. Bigness is therefore an undesirable state of existence, with the converse feelings of intimacy sought in their attempt to dwell in contentment (Gunawardena, 2006).

Theorist, Christian Norberg-Schulz asserted that buildings serve as this 'existential foothold'; a point of reference in both space and time that enables a subject to confirm their existence in relation to it and eventually the world at large (Norberg-Schulz, 1980). Building such structures aims to provide a sense of contentment by contracting the spatial dimensions to an agreeable extent. It is this immersion in constructed intimacy that delivers a sense of comfort, which then becomes the inspiration for imagination and creativity (Bachelard, 1964; 1971). Bigness does not offer this comfort, but evokes the convers. An agreeable building and dwelling therefore instinctively requires the negation of bigness and the complexity it presents.

Bigness also diverges from the practical considerations of building and assembly. If a building is intended as a mediating scale between the human subject and the vastness of the world beyond, anything that moves towards the latter end of this scale spectrum requires the engagement of many units of construction to realise. If a brick corresponds to the scale of the human hand, bigness therefore necessitates a great quantity of bricks and many hands to implement. To a pragmatist, this bigness is costly, unnecessarily complex, and eventually wasteful. The negative criticism of bigness in the 1960s was largely derived from these practical difficulties, which the construction methodologies of the time were simply unable to address.

Furthermore, the inherent complexity of bigness is resisted by purists. To achieve a single objective, bigness requires many components and processes to align. It functions like multicellular organisms, constantly growing and evolving into something different. The purists see this evolving complexity as diluting the integrity of the 'concept'. Their reductive approach cannot tolerate the intricate layering of multiple functions, forms, and meanings. Such a building is no longer defined by a singular idea but instead by many interrelated concepts and interpretations. A large building is no longer a singular gesture but a dynamic system of many interconnected gestures. Its authorship is thus obscured, as multiple authors contribute their diverse narratives. It therefore allows for limitless interpretations, creating confusion for reductive purists, who suffer perpetual anxiety in its presence. (Gunawardena, 2006).

3.2.2 Thesis for the 'mega'

Many surviving ancient monuments suggest that bigness was not completely rejected by efforts to build structures. The Pyramids and Temple of Karnak in Egypt, Great Stupa in Sri Lanka, Great Wall in China, Walls of Ston in Croatia, Colosseum in Italy, Pont du Gard in France, Machu Picchu in Peru, Stonehenge in England, and Angkor Wat in Cambodia... are all examples of bigness. It therefore served purpose and value, whether it was for practical reasons such as security, or to symbolise dominion or divinity. Some also have demonstrated evolution through the ages to serve a multitude of purposes and meanings. Bigness therefore has plenty of historical precedent from many different settings, cultures, and epochs.

These precedents however had not translated to modern building practices, as demands for servicing their needs had made bigness unviable. This limitation of it as being excessive, expensive, and wasteful, had remained valid for many years of modern building. Post 1960 however, it was beginning to be challenged with rapid developments in building services technology. Deep-plan buildings were soon efficiently serviced with circulation networks organised and managed with computerised management systems. These advancements enabled the liberation of buildings from the constraints of human scale, allowing for the construction of large structures that efficiently served multiple purposes. With the advent of modularisation and offsite construction, the capacity to build large structures not only increased, but could also be achieved more rapidly and with greater material efficiency. (Gunawardena, 2006).

The postmodernist quest for purity is no longer an absolute necessity. Technological advancements have afforded buildings the capacity to embody multiple functions and to be influenced by numerous authors. As such, if growth is the objective, buildings must now be capable of delivering this expansion. The purity of authorship is neither required nor respected, and is rarely maintained. The drive for growth demands bigness, with instances already evident in many cities. If left unchecked, such bigness has the potential to evolve into small-scale cities themselves (Koolhaas & Mau, 1995).

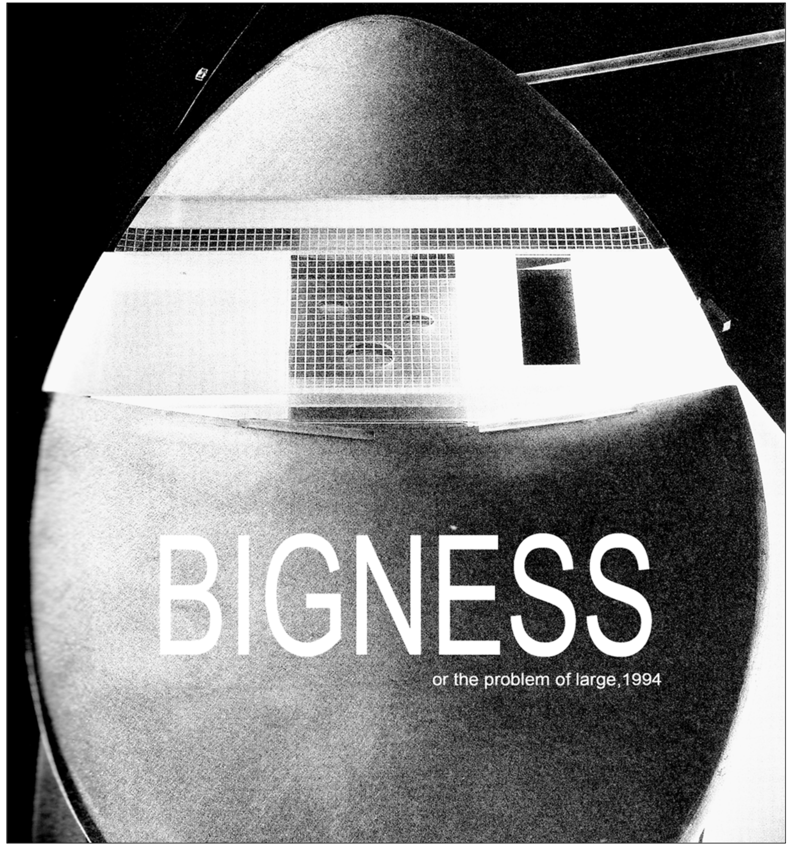


Plate 21. Rem Koolhaas/OMA critique of bigness in, S, M, L, XL (1995).

Integral to this growth demand is the necessity of diversity in usage. Mixed-use and multifunctionality are defining features of contemporary examples of bigness, wherein residential needs are progressively integrated with other traditionally incompatible uses. The notion that urban habitation will persist in townhouses is progressively becoming obsolete. Bigness as a result is emerging as a logical model that evolving urban frameworks will inevitably adopt.

3.3 Archaeology of mega-structural ambition

The foundation of a city is intrinsically linked to the presence of a significant natural asset, such as a port, river, lake, or valley. These geographical features provided the essential conditions for sustaining life, ensuring security, and fostering a sense of identity. Over time, this natural asset became the city's *raison d'être*, serving as a catalyst for the continuous evolution of socio-economic structures. However, the advent of railway networks and mechanised aviation fundamentally altered both the city's capacity, and crucially, its necessity to function as an autonomous entity. As connectivity between cities increased, the establishment of national networks became viable, prompting the emergence of strategic urban planning as a means of defining hierarchical relationships among cities.

Strategic transport networks rapidly emerged as the defining asset in advancing a national agenda for urban habitation. In this context, key railway stations and airports were increasingly recognised as critical infrastructural assets, facilitating exponential growth and economic prosperity. The conception of a city as a result no longer required a natural geographical asset as its foundation. The airport city, where the airport itself serves as the core rationale for its existence, has now become a tangible reality. Humanity has thus successfully introduced manmade infrastructure as a mechanism for establishing cities wherever desired, exemplified by urban settlements such as Las Vegas.

This shift has positioned infrastructure as the fundamental catalyst for broader urban expansion, serving as the cornerstone from which all other human activities can thrive. The concept of the urban megastructure encapsulates this ongoing evolution of manmade infrastructures and their essential role in shaping contemporary and future cities. As a monumental feat of human engineering, the urban megastructure provides a foundational framework, an enduring backbone to cities engaged in continuous transformation. Functionally, it operates as an archetypal model, integrating essential infrastructural elements to support growth and prosperity. Finally, it becomes the infrastructural 'trigger', the vast entity from which all succeeding urban development originates.

The mega-structure serves a strategic function in advancing an urban agenda centred on growth and prosperity. These monumental infrastructures are integral to everyday urban life, seamlessly embedded within the fabric of modern habitation. Bridges, viaducts, grand stations, and airports, exemplify extraordinary feats of engineering, each contributing to the complexity of contemporary cities. As urban populations continue to expand, the significance of mega-structural interventions will become increasingly pronounced within the discourse of urban development. Over time, such large-scale initiatives will transcend their traditional classification within civil engineering, evolving into indispensable 'archi-urban typologies', defining frameworks that shape the spatial and functional dynamics of future cities.

The prophesying of mega-structures as a significant typology within urban development is not without historical precedent in architectural and urban discourse. Following the post-war reconstruction years, the 1950s and 1960s in Europe witnessed a surge of optimism concerning the future of its cities. During this period, socialism and capitalism fiercely contended for ideological dominance, with the Cold War stimulating a wave of pioneering thought in urbanism and architecture. The 1950s marked the introduction of Constant Nieuwenhuys' *New Babylon*, a utopian, anti-capitalist vision characterised by interconnected, transformable structures that came to be known as mega-structures (Wigley & Nieuwenhuys, 1998). Meanwhile, the successful launch of *Sputnik-1* in 1957 heralded the beginning of the space race, inspiring a second era of mechanised ingenuity. This period saw the emergence of a distinctly Futurist perspective, as urban theorists and architects, including Antonio Sant'Elia, Buckminster Fuller, and Yona Friedman, drew upon past visionary works to conceptualise a new era of cities (Crompton, 2001; Cook, 1991). Their proposals reflected an unrelenting enthusiasm for the novel potentials and trajectories that urban development could pursue, fundamentally reshaping architectural and infrastructural aspirations.

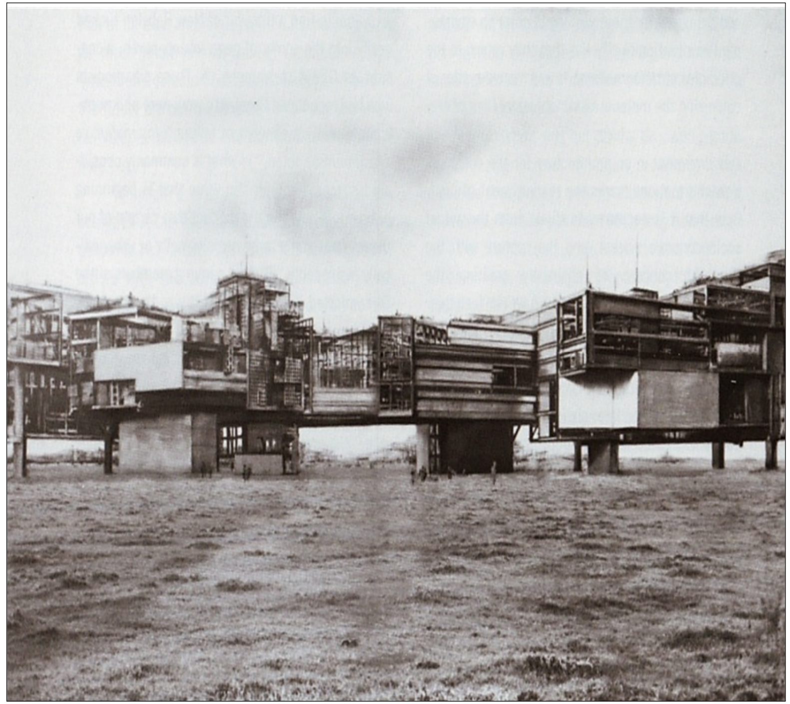


Plate 22. Constant Nieuwenhuys' New Babylon in elevation.

Within this context, the mega-structure as an 'archi-urban' strategy for urban habitation was rigorously explored by theorists of the era. Notably, by two influential groups, Archigram in London and Superstudio in Florence. They developed distinct theoretical propositions on mega-structural urban visions. While these broadly conformed to the overarching archetype of the mega-structure, their interpretations diverged significantly, reflecting contrasting ideological perspectives.

Archigram approached their thesis from a pro-consumerist perspective, drawing inspiration from technological advancements to envision a radically new urban reality (Crompton, 2001; Cook, 1991). In contrast, Superstudio articulated an anti-consumerist perspective, critiquing the unchecked expansion of capitalist-driven urbanism (Lang & Menking, 2003). Meanwhile, Cedric Price's *Fun Palace* (1964) presented yet another conceptual departure, prioritising self-determinacy and incorporating what was then the nascent phenomenon of information technology, as a pivotal force in shaping the future of modern urban living (Mathews, 2005). These explorations exemplify the rich theoretical discourse surrounding mega-structures and their potential role in redefining urban environments. The arguments for cities with mega-structural entities thus were logically presented; structured with ample research and speculation based on projecting emerging trends. As with any endeavour involving speculations and forecasting, their arguments however failed to account for every eventuality. Archigram for instance failed to acknowledge the scarcity of material, and naively believed that changing needs could be satisfied by a never-ending supply of new things. Their concept of the *plug-in city* (1964) accordingly expected a continuous supply of a range of new 'plugs' to satisfy man's ever-changing desires (Crompton, 2001). The over-neutrality of the frame in Price's *Fun Palace* in contrast, affected indifference as it presented very little to stimulate and react against (Mathews, 2005). Such criticisms eventually perpetuated prejudice that condemned the mega-structure as an idea that *should* not survive beyond the 1960s. The eventual aesthetic of such endeavours, which Pater Cook had claimed as 'heroic' (Cook, 1991), soon became 'villainous' to such prejudicial perspectives.

It is essential to recognise that all endeavours in mega-structural thinking have encountered limitations and shortcomings. However, forecasting strategies for future urbanism inevitably involves navigating uncertainties, making the prediction of every eventuality an unattainable task. For instance, Archigram could not have anticipated the severity of the oil crises of the 1970s, which subsequently led to a heightened emphasis on sustainability. The challenges associated with mega-structural developments must therefore be evaluated in relation to the prevailing values and trends of their time, as well as the fundamental issues they then sought to address. The pertinent question that arises is whether there remains a viable future built upon the conceptual foundations laid by theorists such as Archigram and Cedric Price. In essence, could mega-structural interventions continue to evolve within contemporary cities while accommodating the pressing concerns and emerging trends of the present day?

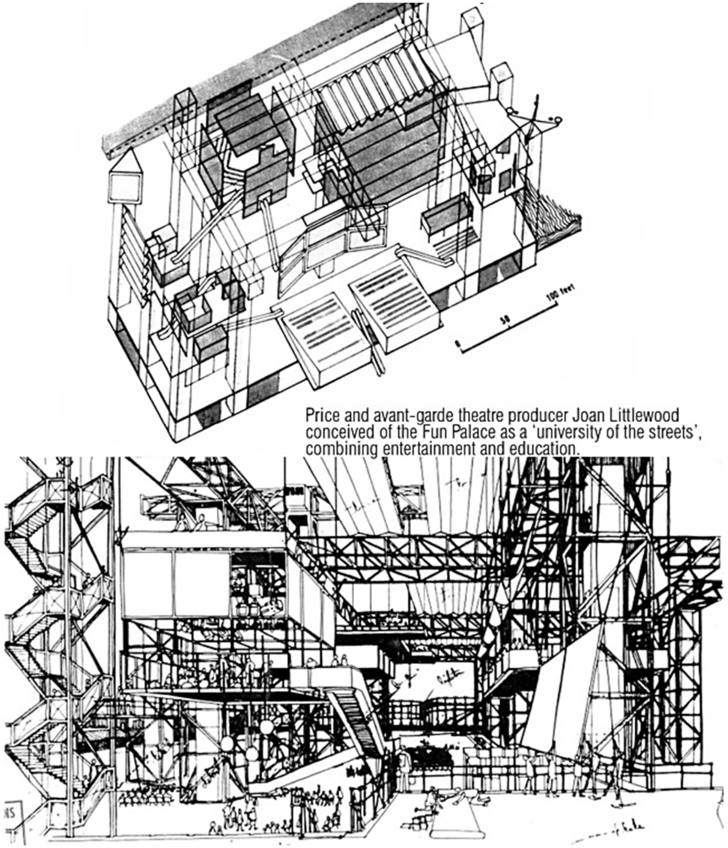


Plate 23. Cedric Price's Fun Palace (1964).

3.4 Presumptions

Mega-structures are found throughout modern urban environments. Motorway flyovers are navigated, bridges are crossed, and tunnels are passed through routinely, with little acknowledgment of these infrastructural archetypes. Yet, when examined in the context of human habitation, vehement opposition is often expressed by architects. New explorations of mega-structural ideals are frequently dismissed as irrational, paradoxically without any substantive justification.

Mega-structures and large-scale urban projects have been implemented worldwide and continue to be developed with increasing regularity. As architect Rem Koolhaas predicted in the 1990s, the phenomenon of 'Bigness', as he had termed it, is progressively resurfacing within both architectural discourse and urban practice (Koolhaas & Mau, 1995). Long-standing concerns regarding efficiency and technical feasibility are gradually being addressed through advances in technology and management systems. Furthermore, critiques of experimental approaches, such as those pioneered by Archigram, have provided contemporary proponents of mega-structures with the insights needed to mitigate common challenges.

Consequently, mega-structural infrastructure is once again emerging as a viable urban typology, with Koolhaas and his OMA's early exploration of Bigness at Euralille in the 1990s, serving as a tangible demonstration of its renewed potential.

Plate 24. Brooklyn Bridge, (completed in 1883).

A mega-structural intervention in Redcliffe offers the opportunity to reconcile historical critiques with contemporary urban priorities. Drawing from the works of Archigram, Superstudio, and Cedric Price, such an approach must integrate adaptability and socio-economic responsiveness. While future urban conditions remain uncertain, identifying key trends, such as population growth, resource scarcity, and sustainable development, is essential.

Today, sustainability is a dominant concern, shaping urban planning and infrastructure. Any new mega-structure must embrace environmentally conscious design, fostering resilience and long-term urban viability. By prioritising sustainable principles, such interventions can redefine large-scale infrastructure as both a practical necessity and a progressive framework for modern urban evolution.

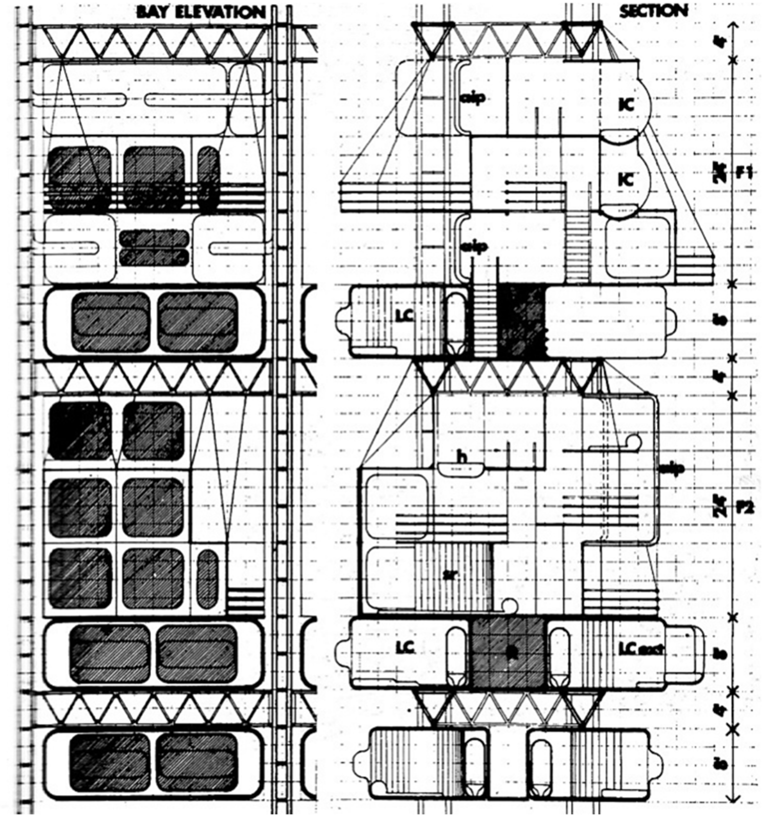


Plate 25. Archigram Hornsey Capsules 1965-6, by Peter Cook: family cages (elevation and section).

This design thesis explores the concept of the urban mega-structure within a strategically positioned site in Redcliffe and its relationship with the broader city of Bristol. It proposes a phased mega-structural strategy aimed at reinforcing Redcliffe's integration within the wider urban framework (Gunawardena, 2008).

In response to critiques of Archigram and Cedric Price's experimental ventures, the project advances an urban cultivation agenda that directly addresses resource scarcity and sustainability. Rather than serving only its immediate occupants, this intervention aspires to foster a resilient, self-sustaining urban environment that benefits Redcliffe as a whole, ensuring long-term viability within the evolving dynamics of contemporary urbanism.

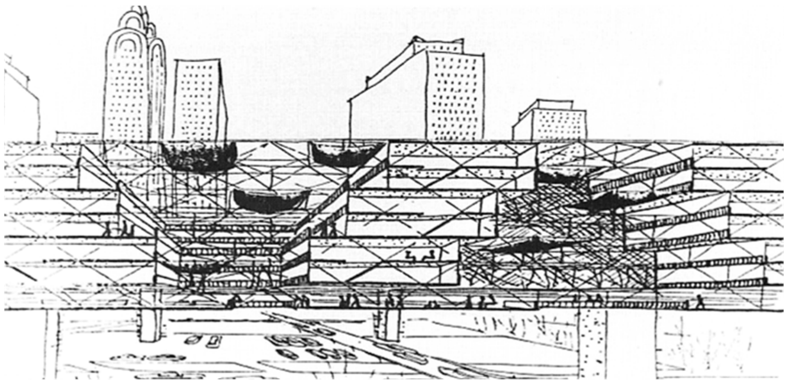


Plate 26. Yona Friedman's proposal for a spatial New York (1956).

3.4.1 Euralille, an urban case-study in bigness

Background

The project was initiated following the 1986 Franco-British agreement for the construction of the Channel Tunnel, alongside the 1987 accord with Northern European nations to expand the TGV network. Initially, the Paris-Brussels line was intended to bypass Lille. However, due to strong lobbying from local interests in 1987, the decision was made to route the TGV line through central Lille.

Lille's geographical position is uniquely advantageous, situated between London, Paris, and Brussels, placing it within proximity to some of Europe's most densely populated and economically vibrant regions. At the time, Lille's economy was unstable, with industrial decline pushing the city towards greater uncertainty. The introduction of the TGV line and station was envisioned as a catalyst for revitalisation, transforming Lille into a hub for European activity and fostering a renewed sense of prosperity amidst its economic downturn.

The brief for the project

Pierre Mauroy, Lille's longstanding Mayor and former French Prime Minister, was the central figure behind this ambitious vision. Under his leadership, a public-private study partnership was established in 1988 to conduct feasibility studies and develop an urban project brief. The proposed site, adjacent to the existing Flandres Station, had remained vacant due to military ownership and was thus a publicly controlled greenfield site (Levene, 1998).

The initial objective was to construct a new TGV station, with an international business centre positioned between the two railway hubs. To mitigate competitive conflicts, the plan incorporated a diverse programme, including offices, services, retail spaces, housing, public areas, cultural facilities, and other urban amenities. This development was conceived as 'Euralille', not merely an extension of Lille, but a newly established city within walking distance of the old centre (Koolhaas & Mau, 1995; Bertolini & Spit, 1998).

To realise this vision, a master architect was required to oversee development. Following oral presentations by eight prominent European architects, including figures such as Claude Vasconi and Norman Foster, Rem Koolhaas was appointed as master planner in 1989. His selection was justified by his holistic vision of the 'city', rather than a singular architectural project (Bertolini & Spit, 1998).

Koolhaas' practice, the Office for Metropolitan Architecture (OMA), formulated the masterplan through continuous consultation with Pierre Mauroy, facilitated by the executive director of Lille, Jean-Paul Baïetto. By 1990, a public-private development partnership was formed to implement this ambitious urban initiative, marking the emergence of 'Euralille' as a transformative model of modern city planning (Bertolini & Spit, 1998; Levene, 1998).

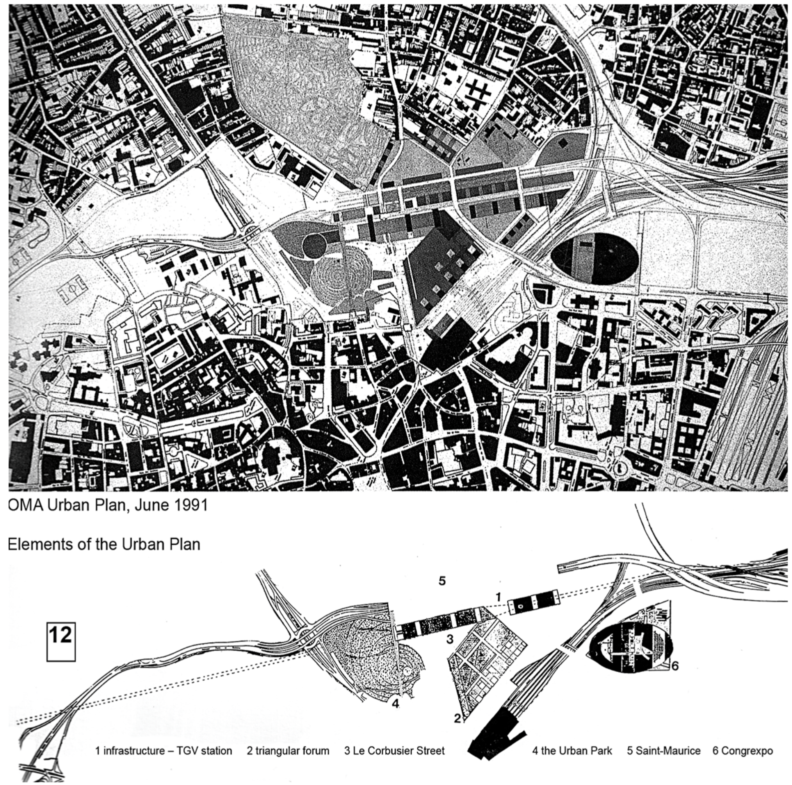


Plate 27. Euralille Masterplan, by the OMA, (Levene, 1998).

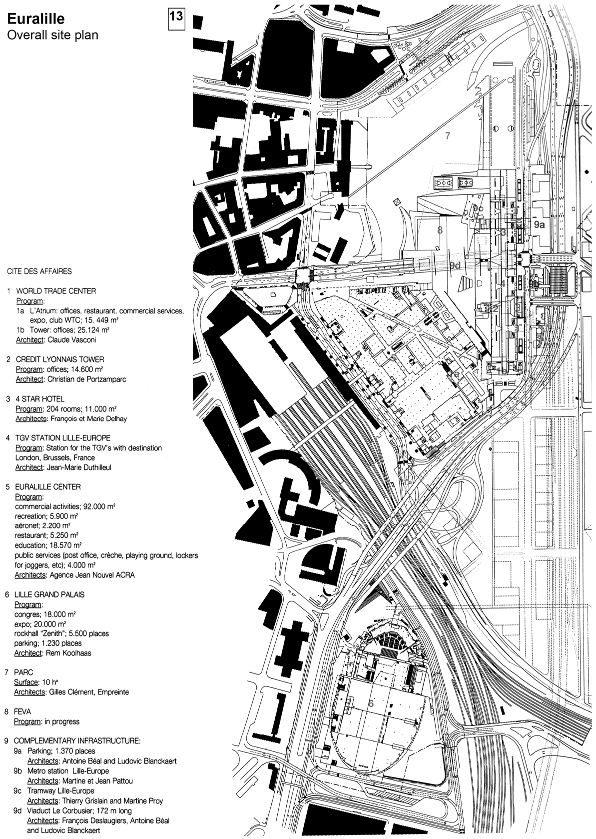


Plate 28. Euralille detailed Masterplan, by the OMA, (Levene, 1998).

Scheme development

From the outset, Rem Koolhaas and the OMA were captivated by the boldness of the scheme. The endeavour was defined by a commitment to radical innovation while operating within the constraints of the existing context, requiring a 'quantum leap towards a future that was both exotic and imminent' (Bertolini & Spit, 1998). The development of the masterplan was progressively shaped by the exceptional political and client support received, resulting in an increasingly ambitious trajectory. However, due to financial constraints, the simplification of the initial proposals was unavoidable.

Euralille and the 'Generic City'

Euralille represents a distinctive urban programme, diverging from conventional classifications as either an urban extension or a new town. It has frequently been characterised as an 'instant city,' appearing as though it has been abruptly deposited into its environment, its architectural composition marked by a striking heterogeneity in style and period (Meade, 1994). For some observers, Euralille presents a stark and jarring contrast, particularly when juxtaposed with Lille's historic centre, with certain perspectives regarding it as emblematic of cheap, uninspired modern junk (Menu, 1996). Such descriptions underscore a sense of astonishment, reinforcing Euralille's unique positioning in terms of both its geographical context and the architectural forms it has engendered.

The project has demonstrably provoked strong and divergent reactions, generating a profound level of intrigue. As a result, it may be regarded as a success in fulfilling its underlying hypothesis of cultivating interest and attracting individuals to Lille. In its current form, Euralille functions as a transitional urban space where commerce, employment, and daily life converge, while Lille's historic core, influenced by its presence, has experienced a renewed sense of dynamism through extensive revitalisation and renovation (Balmond, 2003; Betsky, 2003; Gunawardena, 2006).

This phenomenon aligns with the broader notion of urban regeneration through disruption, an approach that underscores the potential of bold architectural interventions to catalyse the regeneration of declining urban areas. This idea of 'shocking the old to revitalise it', is something that Koolhaas expressed in his manifesto of *The Generic City* (Koolhaas & Mau, 1995). In this manifesto, he described the need for cities to be rejuvenated by shocking its urban fabric to address modern needs, without being restricted by nostalgic attachments. Euralille stands as an illustrative example of this concept, demonstrating how contemporary urban forms can facilitate renewal by addressing present-day requirements, free from the constraints of historical precedents concerning scale, stylistic continuity, and structural organisation (Gunawardena, 2006).

At the core of Euralille's urban programme is the concept of movement and spatial positioning. Contemporary society is increasingly defined by the proliferation of information, cyberspace, and virtual realms, gradually eroding traditional notions of identity. This perspective frames Koolhaas' approach as a liberation from the constraints imposed by notions of place, region, and character. Consequently, his work at Euralille appears intentionally anti-contextual, advocating for a shift from physical space to digital domains. Public space within Euralille thus functions predominantly as an environment of transition and mobility (Dovey, 1998).

The foundational premise of the project was intrinsically linked to its geographical location, positioned within an hour of Paris and two hours of London, underscoring its strategic significance as a European hub of connectivity. The concept of movement as a defining urban characteristic is further reinforced by the idea that Lille itself 'would redefine the idea of *address'* (Koolhaas & Mau, 1995).

Movement and its global implications were similarly explored by Koolhaas in *The Generic City*, wherein the role of the airport was emphasised as a central component of urban identity, described as a quarter of the city and, at times, its very reason for existence (Koolhaas & Mau, 1995). Although Euralille is structured around a high-speed train station rather than an airport, its status as a city of movement remains equally significant. In this context, the TGV station serves as its nucleus, the pivotal element from which the rest of the urban fabric has evolved (Gunawardena, 2006).

Plate 29. Euralille viewed from Lille.

In summary, Euralille as an urban programme, sought to achieve three distinct objectives:

- *Disrupt the established urban fabric,* to provoke new responses and stimulate engagement.
- *Detach itself from nostalgic associations with superficial notions of identity,* favouring a more forward-looking approach.
- *Leverage its strategic geographical positioning,* emphasising its significance as a key node within the broader European framework of movement and connectivity.

Through these principles, Euralille exemplifies a contemporary urban model that prioritises innovation, adaptability, and spatial fluidity, over traditional urban continuity (Gunawardena, 2006).

Euralille and "Bigness"

From its inception, those in authority recognised that Euralille could not be conceived through a singular architectural gesture. Accordingly, a master planner was selected through oral discussions rather than a conventional design competition. Koolhaas was chosen because he "had a vision of the city, not of a project" (Bertolini & Spit, 1998). His role was to serve as the director of numerous architectural interventions and to coordinate various stakeholders, including clients, planners, and other architects.

Plate 30. Westfield Euralille Centre, designed by Jean Nouvel (1994).

Koolhaas possessed a clear understanding that Euralille as a programme, had to engage with the city in its entirety. He therefore acknowledged that the project extended beyond the representation of a singular architectural act. To him, it embodied the very essence of programmatic "Bigness" (Koolhaas & Mau, 1995).

As a result, the numerous architectural interventions were assigned to a variety of designers. Koolhaas' OMA, despite holding the authority to define these architectural elements in extensive detail, deliberately refrained from doing so. Instead, they provided abstract volumetric forms with only their strategic connections delineated, granting the other architects autonomy to shape their own contributions to the emerging urban landscape. "As Michelangelo liberated masterpieces from inert blocks of marble, so will the different architects… liberate genius from our boring slabs" (Koolhaas & Mau, 1995). This collaborative approach, involving architects such as Jean Nouvel, Christian de Portzamparc, and Claude Vasconi, exemplifies Koolhaas' theory that Bigness necessitates more than the singular vision of one architect, instead benefiting from a multiplicity of creative inputs (Gunawardena, 2006).

Euralille manifests as a series of imposing architectural masses, offering a stark contrast to the finer scales of Lille's historic urban fabric. The most explicit embodiment of Bigness is the large oblong, egg-shaped structure formerly known as the Congrexpo. Despite its relative detachment from both the TGV station and the city centre, the Congrexpo asserts its own distinctive presence, functioning as a self-contained urban entity. As a hybrid, multi-use structure spanning 52,000 m², it exemplifies the concept of Bigness in its capacity to operate independently within the broader urban composition.

Plate 31. The Congrexpo, now Lille Grand Palais (completed in 1994).

"Entering Lille Grand Palais (Congrexpo) does its massive scale and spatial complexity become evident" (Meade, 1994). "The Congrexpo acts like a city within a city" (Balmond, 2003). Jean-Louis Cohen had similarly observed that it "obviously forms a part of the 'Bigness' concept that Koolhaas has focused on for a while" (Menu, 1996). In a rare interview, Koolhaas himself articulated the conceptual foundation of the Congrexpo, stating: "I realised that the potential of this project was related to ideas advocated in *Delirious New York*". When questioned about whether the Congrexpo exemplifies Bigness, he affirmed, "yes, absolutely... I wanted to emphasise the possibility of creating whole things... Euralille is a fine example of such an effort" (Menu, 1996). These statements solidified the definitive connection between Koolhaas' theory of "Bigness" and its materialisation in both the Congrexpo and Euralille at large, demonstrating the concept's application in tangible urban reality.

As in much of the OMA's work, the aesthetic dimension of Euralille remains largely undefined, as though its visual characteristics emerge incidentally rather than as a deliberate aspect of the design process. It appears that aesthetic considerations are subordinated to broader urban and programmatic concerns, rendering them almost inconsequential in the project's discourse. However, as Cohen had observed, the extensive collection of drawings and models illustrating slender highways and suspended footbridges, suggested a deliberate engagement with visual imagery. While Koolhaas demonstrated an "undeniable ability to create graphical extravaganza", Cohen contends that this expressive visual language does not fully translate into the completed built environment, resulting in a divergence between conceptual representation and realised form (Menu, 1996).

Plate 32. Westfield Euralille Centre, designed by Jean Nouvel (1994).

4.0 Design development and process

4.1 Concept and logic diagram

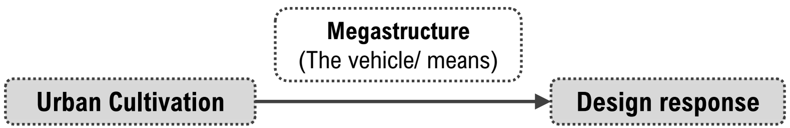
4.1.1 Research focus

As mentioned earlier, this design thesis with a clear and definitive purpose, aims to address the challenges associated with advancing an agenda of urban cultivation within Redcliffe. In approaching this objective, it makes a deliberate decision not to reiterate the strategies previously proposed by Andre Viljoen (2005). Instead, it seeks to contribute an additional strategy to the existing discourse.

Urban Cultivation Strategies = [Green wedges], [Green belts], [Green Walkways/paths/ and bands] ... + **[GREEN MEGA-STRUCTURE]**

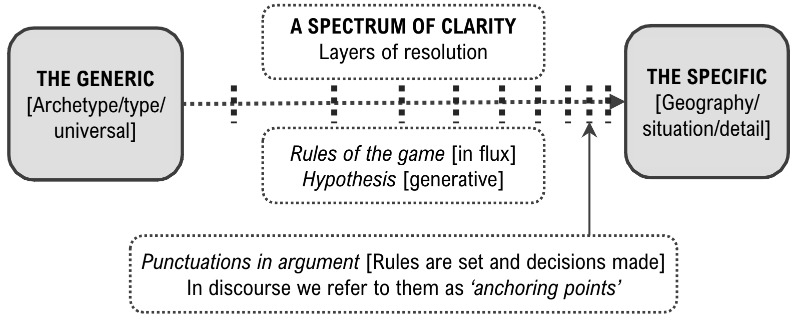
“The thesis in its specific focus accordingly considers the challenges of achieving a viable practice of urban cultivation, through the means of a green mega-structural system.”

Diagram of research focus



The design response does not assert itself as an absolute or all-encompassing solution. Rather, it is presented as one of many possible strategies, each contributing to a broader, multifaceted approach.

Argument diagram



The macro-to-micro relationship is invariably framed between the opposing dimensions of the generic and the specific. An urban agenda, in both its programme and operational framework, must engage with the fundamental principles of urban habitation that apply universally to all individuals who interact with such an environment. As a result, the macro-level argument inevitably positions its equilibrium to the left of centre within the outlined conceptual framework.

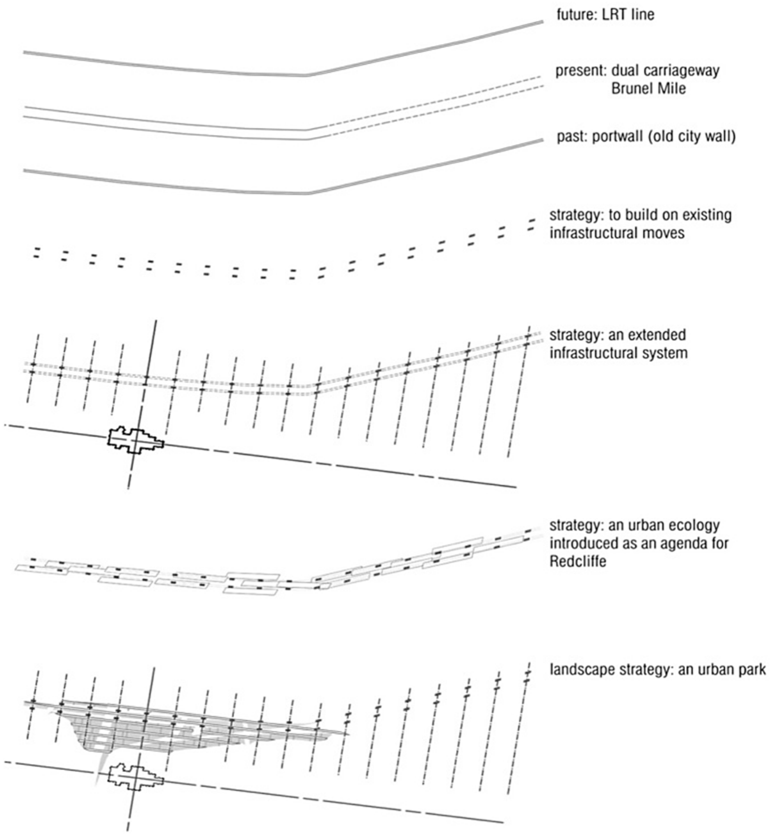


Plate 33. Superimposing systems at Redcliffe.

In the context of this design thesis, this condition is embodied by the mega-structural system, which in both its conception and execution aspires to achieve a degree of generic or archetypal applicability, constrained only by the conditions of the site and the broader urban milieu. This ambition ensures that the urban gesture remains accessible to diverse interests, allowing its underlying generic values to be adapted and clarified in response to specific situational needs.

The mega-structure functions as a foundational platform, with minimal fixed points of discourse, thereby enabling successive contributors to construct their own narratives upon it. Central to this proposition is the question of authorship, specifically, the extent to which an urban intervention acquires or retains agency. Drawing upon the case study of Euralille, Rem Koolhaas underscored the necessity of multiple architectural gestures rather than a singular design perspective. In alignment with this notion, the urban mega-structure articulated in this thesis presents itself as an evolving and perpetual proposition, continuously defined, redefined, and reassessed by successive authors, each responding to the values and imperatives of their respective times (Gunawardena, 2008).

It is essential to recognise that within this thesis, certain components, such as the mega-structural system, are deliberately positioned towards the left of the conceptual framework, maintaining a broader and more generic stance. Conversely, other elements, such as habitation and cultivation, as represented by the accommodation decks, are explored with precise specificity. This strategic approach is purposefully devised to reflect the responsibilities of authorship in navigating and responding to macro-micro design methodologies, ensuring an equilibrium between overarching urban principles and detailed interventions (Gunawardena, 2008).

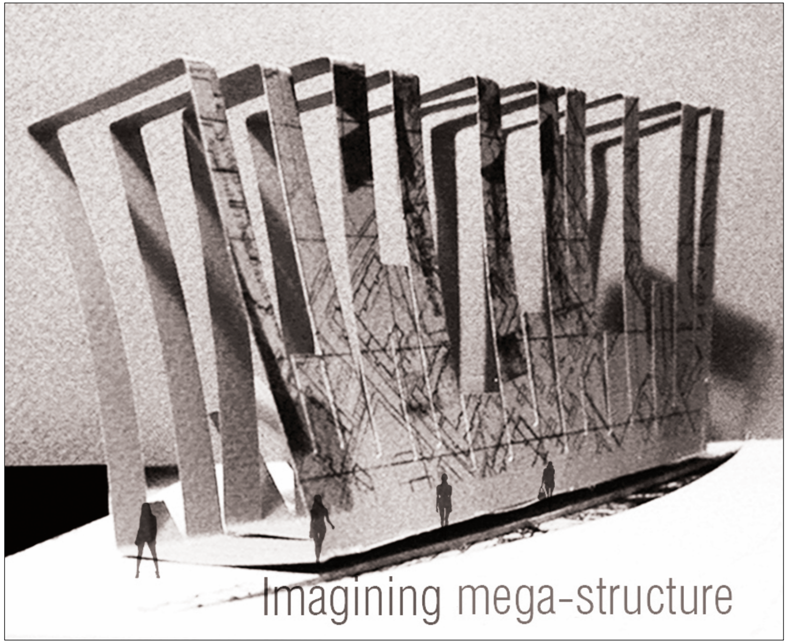


Plate 34. Proto megastructure, paper model.

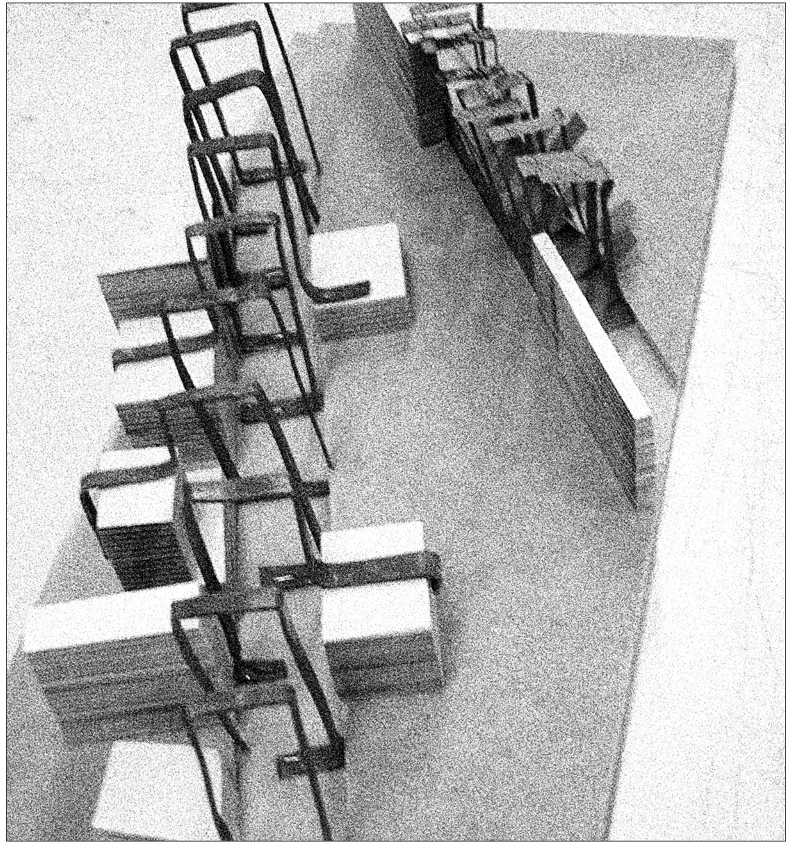


Plate 35. Proto megastructures, lead and plywood model.

Plate 40

Plate 30

4.2 Urban-scale: Mega-structural System

The urban masterplan establishes a linear sequence of mega-structures aligned along the historic course of the Portwall, extending from Redcliffe Bridge to the opposite riverbank, culminating at the rear of Temple Meads Station. These structures are systematically arranged on a 40-metre grid, intentionally offset from the axis of St. Mary Redcliffe, which simultaneously serves as the organising framework for the cultivated urban park. The urban park is conceived in its initial phase as a cultivated decontamination strategy, spanning a 5–15-year timeframe. This is subsequently succeeded by the implementation of a permanent productive cultivation approach, integrated with a network of public footpaths to enhance accessibility and engagement.

4.2.1 System service life

Most infrastructural developments, including bridges, viaducts, and railway lines, are designed with anticipated life spans exceeding a century. Given the substantial resource investments required for their construction, these structures are engineered to maximise functionality and longevity, ensuring their viability as sustainable ventures. In alignment with this principle, the envisioned mega-structural system at Redcliffe is intended to achieve a 200-year active service cycle.

This longevity is integral to its broader programme and hierarchical framework, reinforcing its capacity to adapt over time while maintaining its foundational role within the urban landscape.

4.2.2 Mega-structure principles

A mega-structure functions as a foundational framework, devoid of inherent specialisation, yet designed to accommodate and support a diverse array of auxiliary programmes. To fulfil this role effectively, it must incorporate three fundamental requirements:

- Stability: The structural integrity must ensure self-support while accommodating anticipated dead and live loads. Significant engineering expertise is required, with unitised elements collectively contributing to overall stability (refer to Chapter 5.0).
- Servicing: The integration of essential systems that sustain life, including water supply, drainage, sewerage, and energy infrastructure, is crucial to its long-term viability.
- Access: The framework must facilitate seamless movement, encompassing ingress and egress, service provisions, emergency escape routes, and fire safety measures.

Beyond the standard archetype of the mega-structural unit, subsequent programs have the option of modifying this basic unit by adding layers of resolution. This thesis highlights two such iterations:

1. Hydroponic green wall-clad south façade, (utilised as the buffer strategy that connects the mega-structure with the ground plane).
2. Glazed panel strategy, with an option to switch the glazing panel with a perforated stainless steel mesh panel.

Plate 26

Plate 27

Plate 43

Plate 4

Plate 5

Plate 24

4.3 Building scale: Institute of Urban Cultivation

> *"Our cities should be farms"*
>
> Architect, Andre Viljoen (2005)

The 'gateway project' within the proposed mega-structural system integrates 'closed loop' technology to advance urban cultivation, serving both as a research platform and a commercially viable enterprise. It provides individuals from diverse backgrounds with the opportunity to engage with principles of self-sufficiency, food cultivation, and sustainable practices. From novice growers seeking to develop basic agricultural skills to researchers experimenting with advanced cultivation strategies, the project creates an inclusive framework for knowledge development (Gunawardena, 2008).

By bridging the gap between beginners and experts, the initiative cultivates a dynamic urban environment where habitation and education are interwoven. It promotes interdisciplinary collaboration, fostering innovation in sustainable food production, while reinforcing the broader vision of integrating productive landscapes within the built environment. Ultimately, it aspires to redefine urban sustainability through participatory engagement and applied research.

4.3.1 Garden accommodation decks

The Institute's accommodation schedule is designed around a standard 'deck' type, fostering the development of gardening communities. Each deck functions as a self-contained unit, housing two advanced researchers alongside ten beginner units, known as Garden Rooms. This structured arrangement facilitates the intermingling of expertise, allowing knowledge to be passed from experienced practitioners to novices, strengthening the community's collective understanding of cultivation (Gunawardena, 2008).

The deck's physical design incorporates a distinct 'head' and 'tail.' The head, characterised by its triangular form, features a communal kitchen and decked space, encouraging informal knowledge exchange. In contrast, the tail provides a more secluded setting, suitable for private discussions.

Corridors within this system are generously sized, with a minimum width of 2200 mm, allowing them to function as a 'street in the sky.' Like traditional streets, these spaces enable occupants to personalise their surroundings, provided they do not obstruct movement or safety protocols. This flexibility supports expanded cultivation practices, such as positioning hydroponic trays outside individual garden room thresholds, fostering unique deck identities, and a culture of competitive gardening (Gunawardena, 2008).

4.3.2 Entire building program

The following outlines spatial allocations and functional zones for all the Institute's cultivation, research, and community facilities.

Facility	Quantity
General lease 'Garden Rooms'	65
Researcher quarters, 'Garden Research Units'	15
Permanent staff quarters	10
Permanent staff researcher quarters	3
Research Laboratories	3
Algae Research Unit	1
Hydroponic Research Library	1
Hydroponic farm produce retail outlet	1
In-house bar	1
Fram-to-table café/restaurant	1

Total building area: **14,150 m²**

Footprint area: **1,265 m²**

Cultivation area: <u>2375 m²</u> =

Production capacity: to feed 198 families of 4 for a year.

Key room functions

Garden Rooms

Private ensuite rooms equipped with personal hydroponic growing units, enabling cultivators to nurture plants directly within their living quarters for relaxation and learning.

Garden Research Units

Advanced cultivation chambers featuring high-tech hydroponic and aeroponic systems for experimental plant growth and botanical research by experienced cultivators.

Research Laboratories

Central research facility outfitted with analytical instruments and controlled environments for conducting scientific experiments in plant biology and cultivation techniques.

Algae Research Unit

Specialised lab focused on studying algae species, optimising bio-reactor growth conditions, and extracting bio-nutrients for advanced cultivation applications, sustainability, and biofuel development.

Farm-to-Table Café/Restaurant

A sustainable dining space serving fresh, seasonal meals made from on-site grown produce, showcasing cultivation innovations through culinary experiences and fostering community engagement.

Plate 14

Plate 15

Plate 16

Plate 17

4.3.3 Building occupancies

This section outlines occupancy types, durations, and responsibilities within Institute-managed urban cultivation spaces and associated research environments (Gunawardena, 2008).

Anticipated occupational models

The following leasing models reflect a strategic approach to accommodating diverse urban occupancies, ensuring flexibility while catering to both specialist and general user needs.

- **Short-term leases** (4–8 weeks)

  Designed for individuals engaged in portable hydroponic gardening. This user group currently represents the lowest probability of uptake.

- **Mid-term leases** (8–16 weeks)

  Targeted at frequent yet transient visitors to the city, such as exchange students, temporary employees, and short-term professional transfers (secondments/sabbaticals). At present, this category exhibits the highest probability of occupancy.

- **Long-term leases** (16 weeks to one year)

  Intended for individuals with recurring yet intermittent residency patterns in the city, for instance, those working in Bristol for only two to three days per week while residing elsewhere, such as Bath or London, for the remainder of the week.

Occupational modes – Lease Agreements

The following outlines the leasing framework for Garden Rooms and Garden Research Units. It defines minimum and maximum lease durations, extension conditions, and usage terms. These guidelines ensure clarity and consistency in occupancy arrangements, supporting both short-term and extended use of our facilities.

- Minimum lease duration for a Garden Room: 4 weeks.
- Minimum lease duration for a Garden Research Unit: 8 weeks.
- Maximum single lease agreement duration: 1 year.
- Lease extensions: Subject to availability.

Managed Garden Sponsorships

The following explains how sponsorships are structured for managed garden crops. Sponsorship costs are crop-dependent and calculated based on average consumption per person over a 4-week period. This model supports sustainable food production while allowing individuals to contribute directly to the cultivation of specific crops.

- Crop-dependent sponsorships.
- Calculated based on average consumption per person per 4-week interval.
  - ✓ Example: Sponsorship for a 4-week supply of tomatoes = £xx.xx per person.

Assistance and Maintenance Packages

The following details the support services available to Garden Room and Research Unit occupants. It includes maintenance packages for hydroponic systems, harvesting support during absences, and access to expert guidance through seminars and individual sessions. These offerings ensure flexible, well-supported engagement with cultivation and research activities.

- Maintenance assistance package for Garden Room units.
  - ✓ Includes upkeep of local hydroponic systems and harvesting during occupant absence.
- Advanced hydroponics tutorials and expert advice.
  - ✓ Delivered through scheduled research seminars (invoiced per person per seminar).
- Individual advice sessions.
  - ✓ Available via appointment through the research unit (invoiced at an hourly rate).

These services offer flexible, structured assistance for Garden Room and Garden Research Unit occupants engaged in cultivation and research (Gunawardena, 2008).

Gardner's Credits Scheme

The Gardener's Credits Scheme enables Garden Room occupants to return surplus produce in exchange for credit points. These credits may be redeemed for a variety of benefits, including meals at the onsite restaurant, gardening supplies, and sponsorship contributions. This initiative supports a closed-loop food cycle, encouraging sustainable practices and active participation in urban cultivation. By linking personal cultivation efforts to tangible rewards, the scheme fosters a sense of ownership, promotes experimentation, and strengthens the project's social and ecological goals. It is a key component in building a resilient, community-driven model of sustainable urban living.

Credits may be used for:

- Meals at the onsite restaurant, supporting a closed-loop food cycle within the urban cultivation framework.
- Purchasing growing supplies, facilitating continued cultivation and experimentation.
- Sponsorship payments, allowing participants to contribute to the broader sustainability initiative.

This approach fosters a dynamic, self-sustaining system that incentivises engagement with urban cultivation while reinforcing sustainable economic and social interactions within the project.

Plate 36. Advanced hydroponic units with automated nutrient tracks.

4.3.4 Applying hydroponic methods

Over recent decades, there has been a marked shift in public consciousness toward sustainable living, driven by environmental concerns and the need to reduce carbon emissions. This has led to increased interest in self-sufficiency and local food production, particularly in urban contexts where traditional agriculture is constrained by space and soil contamination (Resh, 2001; Jensen, 1997).

Urban environments, characterised by constant spatial and infrastructural transformation, pose significant challenges to conventional cultivation. The unpredictability of urban development renders static models of optimal growing conditions ineffective. As such, sustainable urban agriculture must adopt controlled and adaptable systems that align with the structured nature of urban life (Nelkin, D. & Pollack, M., 1977; Gunawardena, 2008).

Hydroponics, a method of soilless cultivation, offers a viable solution by enabling precise control over environmental variables such as nutrient delivery, water use, and light exposure. This method has been historically employed in regions with poor soil conditions and has gained renewed attention for its efficiency and adaptability in dense urban settings (Cooper, 1979; Resh, 1981).

Furthermore, hydroponics has been explored in extreme environments, including space missions, where the US National Aeronautics and Space Administration (NASA) had investigated its potential for sustainable food production in closed-loop systems (Wheeler, et al., 1996). These studies underscore hydroponics' relevance not only for terrestrial urban agriculture but also for future off-world habitation.

In summary, hydroponics represents a strategic response to the limitations of urban agriculture, offering a controlled, efficient, and sustainable method of food production that aligns with contemporary environmental and spatial challenges. Furthermore, its scalability and adaptability make it suitable for integration into educational, commercial, and community-based initiatives, fostering broader ecological awareness and resilience (Gunawardena, 2008).

Plate 37. Advanced hydroponic units with automated nutrient tracks.

Applying hydroponic methods in architecture

In recent years, the architectural discipline has increasingly engaged with hydroponic gardening, primarily as a component of the broader movement toward sustainable and ecologically responsive design. This interest however, often appears to be driven more by the visual and symbolic appeal of greenery, what might be termed as the 'green aesthetic', than by a substantive commitment to ecological functionality. Green roofs and living walls have become emblematic features of contemporary architectural expression, frequently employed to signal environmental consciousness and align with prevailing sustainability narratives (Gunawardena, 2008).

While such integrations may contribute to urban biodiversity, thermal regulation, and air quality improvement, their implementation is not always underpinned by rigorous ecological or agricultural intent. This raises critical questions about the authenticity and efficacy of hydroponic applications in architectural contexts. Are these systems being deployed as functional, productive landscapes capable of contributing to urban food systems and environmental resilience? Or are they primarily serving as aesthetic devices, superficial indicators of sustainability that risk reducing hydroponics to a form of ecological ornamentation (i.e., 'green-washing')?

A more critical and reflective approach is therefore necessary to distinguish between performative sustainability and genuinely integrated ecological design. Only through such scrutiny can hydroponic technologies be meaningfully embedded within the built environment, fulfilling both symbolic and practical purpose (Gunawardena, 2008).

Plate 38. Musée du Quai Branly, hydroponic living wall.

Benefits of using hydroponic cultivation

- Hydroponic cultivation presents a viable alternative to traditional agriculture, particularly in environments where conventional soil-based methods are impractical or unfeasible. This includes urban areas with limited arable land or regions affected by soil degradation (Resh, 1981; 2001).

- One of the most significant advantages of hydroponics is its spatial efficiency. According to Dickerman (1975), a family of four would require approximately 235 square metres of land to produce sufficient vegetables using traditional horticultural methods. In contrast, hydroponic systems can achieve the same yield within just 12 square metres, demonstrating a substantial reduction in spatial requirements (Dickerman, 1975).

- In addition to space efficiency, hydroponics supports accelerated plant growth. For example, tomatoes can reach ripeness within 8 to 10 weeks, cucumbers in as little as five days, and bib lettuce can be harvested within 40 days from seeding (Dickerman, 1975). This rapid growth cycle enables more frequent harvests and improved productivity (see Table 2 for more yields).

- Maintenance demands are also significantly reduced. While managing a 235 m^2 conventional plot may require full-time labour, a 12 m^2 hydroponic unit typically necessitates only a few hours of weekly maintenance. Furthermore, many aspects of hydroponic systems can be automated, further reducing labour intensity (Jensen, 1999).

- Hydroponic cultivation also offers greater control over plant health and consistency. The closed system design minimises exposure to soil-borne diseases and pests, resulting in more uniform crop quality. Additionally, crops can be cultivated out of season, providing year-round production capabilities.
- Contrary to common misconceptions, chemically grown plants in hydroponic systems are not inferior in flavour or nutritional value. Analytical studies have shown no significant deficiencies in vitamin content when compared to traditionally grown produce (Dickerman, 1975; Premuzic, et al., 1998).
- Finally, hydroponics is highly water efficient. Most of the water used in these systems is recirculated, significantly reducing overall consumption compared to conventional irrigation methods (Dickerman, 1975; Resh, 2001).

Crop performance in hydroponic systems

Empirical studies highlight that hydroponic cultivation significantly enhances the productivity of various crop categories under controlled environmental conditions (see Table 2 for yields).

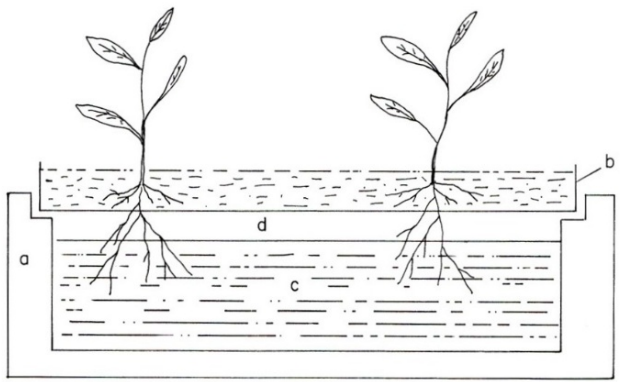
- Leafy greens: Species such as *Lactuca sativa* (lettuce) and *Valerianella locusta* (lamb's lettuce) demonstrate marked yield improvements in hydroponic systems. These gains are primarily attributed to optimised nutrient delivery and precise environmental regulation (Resh, 2001; Jensen, 1999).
- Fruiting vegetables: Crops including tomatoes (*Solanum lycopersicum*), cucumbers (*Cucumis sativus*), and peppers (*Capsicum* spp.) exhibit substantial increases in per-plant yield when cultivated hydroponically (Morgan, 2005; Jensen, 1997; 1997).
- Herbs and medicinal plants: Aromatic herbs such as basil (*Ocimum basilicum*), parsley (*Petroselinum crispum*), and mint (*Mentha* spp.) show enhanced biomass accumulation, likely due to the fine-tuned nutrient management inherent in hydroponic systems (Sheldrake, 1988).
- Root and tuber crops: Although less frequently addressed in the literature, root and tuber crops present notable challenges in hydroponic contexts, primarily due to their spatial requirements and growth morphology (Resh, 2001).

These findings underscore the potential of hydroponic agriculture to improve crop yields, particularly in environments where variables such as light, temperature, and nutrient availability can be carefully controlled. However, considerations such as high initial capital investment, energy consumption, and the need for technical expertise must be factored into assessments of hydroponic systems' scalability, and long-term feasibility (Resh, 2001).

Table 2. Comparative yields: hydroponics vs. soil-based cultivation.

Crop Common Name	Scientific Name	NFT Suitability	Hydroponic Yield	Soil-Based Yield	Units	Reference
Lettuce	*Lactuca sativa*	Excellent – Ideal NFT crop	41 kg/m²/year	3.9 kg/m²/year	kg/m²/year	(Resh, 2001)
Lamb's Lettuce	*Valerianella locusta*	Very good – Light, compact	1585 ± 304 g/m²	1203 ± 304 g/m²	g/m²	(Jensen, 1999)
Chard	*Beta vulgaris* subsp. *cicla*	Good – Moderate root zone	246.78 g/plant	228.22 g/plant	g/plant	(Steiner, 1984)
Eggplant	*Solanum melongena*	Fair – Needs support	7.36 kg/m²	6.47 kg/m²	kg/m²	(Adams, 1994)
Wheat	*Triticum aestivum*	Poor – Not ideal for NFT	1828 kg/acre in 7 days	1762 kg/acre in 7 days	kg/acre/ 7 days	(Jensen & Collins, 1985)
Cantaloupe (var. Alpha)	*Cucumis melo* (var. Alpha)	Poor – Needs space/support	23.18 t/ha	12.55 t/ha	t/ha	(Resh, 2001)
Cantaloupe (var. Emerald)	*Cucumis melo* (var. Emerald)	Poor – As above	23.18 t/ha	7.73 t/ha	t/ha	(Resh, 2001)
Cantaloupe (var. Sin)	*Cucumis melo* (var. Sin)	Poor – As above	23.18 t/ha	4.44 t/ha	t/ha	(Resh, 2001)
Tomato (var. Miramar)	*Solanum lycopersicum* (Miramar)	Excellent – NFT adaptable	7844 g/plant	5118 g/plant	g/plant	(Morgan, 2005)
Cherry Tomato	*Solanum lycopersicum* var. cerasiforme	Excellent – Compact growth	4741.83 g/plant	3513.58 g/plant	g/plant	(Morgan, 2005)
Basil	*Ocimum basilicum*	Excellent – Herbs thrive	388.14 g/plant	326.64 g/plant	g/plant	(Sheldrake, 1988)
Parsley	*Petroselinum crispum*	Very good – Moderate root	414.64 g/plant	342.04 g/plant	g/plant	(Sheldrake, 1988)
Cayenne Pepper	*Capsicum annuum* (Cayenne type)	Good – Needs support	10.8 fruits/plant	8.6 fruits/plant	fruits/plant	(Jensen, 1997)
Sage	*Salvia officinalis*	Good – Compact herb	2286 g/m²	863 g/m²	g/m²	(Adams & Ho, 1989)
German Chamomile	*Matricaria chamomilla*	Moderate – Trial basis	3015 g/m²	962 g/m²	g/m²	(Adams & Ho, 1989)
Jordanian Chamomile	*Matricaria recutita* (regional variant)	Moderate – Similar to German	906 g/m²	411 g/m²	g/m²	(Adams & Ho, 1989)
Thyme	*Thymus vulgaris*	Good – Slow growing herb	1283 g/m²	518 g/m²	g/m²	(Adams & Ho, 1989)
Mint	*Mentha* spp.	Excellent – Spreads easily	3208 g/m²	1320 g/m²	g/m²	(Adams & Ho, 1989)
Strawberry	*Fragaria × ananassa*	Good – NFT adaptable	85 fruits/plant	70 fruits/plant	fruits/plant	(Resh, 2001)
Sweet Pepper	*Capsicum annuum*	Good – Compact varieties	10.95 kg/m²	9.40 kg/m²	kg/m²	(Steiner, 1984)
Bell Pepper	*Capsicum annuum* var. *grossum*	Good – Determinate types	1277.88 g/plant	834.54 g/plant	g/plant	(Morgan, 2005)
Cucumber	*Cucumis sativus*	Excellent – Bush types	4727.38 g/plant	4427.38 g/plant	g/plant	(Jensen, 1997)
Zucchini	*Cucurbita pepo*	Fair – Space needed	21 fruits/plant	17 fruits/plant	fruits/plant	(Adams, 1994)

Deploying hydroponic units



A hydroponic system optimises plant growth through key structural components. The tank, made from glass-reinforced concrete (GRC) or similar materials, provides a stable foundation for the nutrient solution. Positioned above, a wire mesh framework supports plants in a 'seed bed,' ensuring stability and access to essential resources. Galvanised surfaces require a non-toxic protective coating to prevent adverse interactions. The nutrient solution nourishes roots efficiently, while a moisture-rich air space beneath the seed bed enhances root development. This controlled environment fosters healthier plants, improving cultivation outcomes. Research has demonstrated the benefits of this approach in promoting sustainable and efficient growth making it an effective hydroponic solution (Stoughton, 1969).

a. **Tank:** Constructed from GRC or alternative materials.

b. **Framework:** Wire mesh used to support plants in a 'seed bed' positioned above the nutrient solution. Any galvanised (zinc-coated) surfaces require a non-toxic protective coating.

c. **Nutrient solution:** Serves as the primary medium for root system development.

d. **Air space:** Located between the seed bed's bottom and the nutrient solution's surface. This moisture-saturated air promotes root formation, identified as beneficial for plant growth (Stoughton, 1969, p. 6).

The proposed Institute of Urban Cultivation would employ two distinct hydroponic cultivation methods:

1) Continuous flow solution culture; and
2) Static solution culture.

The static solution culture method is recommended for application within individual Garden Rooms. Although it is comparatively less productive than continuous flow solution culture, it offers enhanced operational control at an individual level. Conversely, the continuous flow solution culture will be adopted across all communal, commercial, and research cultivation environments (Gunawardena, 2008).

The unit design illustrated in the following pages corresponds to a continuous flow solution culture system. However, the trays can be readily modified to accommodate a static solution culture if required.

Continuous flow solution culture system

This system utilises a continuous flow solution culture, ensuring a constant movement of nutrient solution past the roots. Compared to the static solution culture, it offers greater ease of automation, as temperature and nutrient concentration adjustments can be efficiently managed within a large storage tank. This centralised approach streamlines monitoring and modifications, enhancing precision and scalability. With the potential to support thousands of plants, the system maximises efficiency while maintaining optimal growing conditions, making it particularly suitable for large-scale communal, commercial, and research cultivation environments (Cooper, 1979).

Nutrient Film Technique (NFT)

The Nutrient Film Technique (NFT) is a continuous flow solution culture system designed to deliver essential nutrients directly to plant roots. In this method, a thin stream of water, enriched with dissolved nutrients, flows through a watertight channel, ensuring efficient nutrient uptake. The shallow depth of the re-circulating stream allows the developing root mat to remain partially exposed to air, maintaining moisture while ensuring a plentiful oxygen supply, crucial for healthy plant growth (Cooper, 1979).

To optimise flow rates, channel slopes between 1:20 and 1:40 are recommended, with the necessary incline provided by supporting racks. Additionally, channel lengths should be maintained within an optimal range of 10 to 15 metres to enhance system efficiency and performance (Cooper, 1979).

Advantages of the NFT System over other methods

- Optimal root exposure:

  Plant roots receive a continuous supply of water, oxygen, and nutrients, ensuring efficient absorption.

- Simultaneous fulfilment of growth requirements:

  Water, oxygen, and essential nutrients are consistently available, creating ideal conditions for healthy plant development.

- Extended cropping periods with high yields:

  NFT supports prolonged cultivation cycles, producing higher-quality crops over time, (see Table 2 for NFT crop suitability).

Drawback of NFT

- Flow interruptions:

  Power outages or mechanical failures can disrupt the nutrient supply, potentially harming plants. To mitigate this, backup power systems or non-grid/onsite generation methods are recommended (Cooper, 1979).

Plate 20

Plate 18

Plate 32

Plate 36

Plate 34

Plate comp plan

Plate L1

Plate L2

Plate L3

Plate L4

Plate L5

Plate L6

Plate L7

Plate L8

Plate L9

Plate 1

Plate 21

Plate 22

Plate 09

Plate 03

Plate 02

Plate 11

Plate 23

Plate 12

Plate 10

Plate 28

Plate 13

4.3.5 Building accessibility and circulation

The Institute of Urban Cultivation is designed to accommodate a maximum occupancy of 250 residents, ensuring efficient movement and accessibility throughout the facility. The building will be served by 11 access cores, all of which are integrated into the mega-structural system. These cores would facilitate vertical and horizontal circulation, optimising spatial connectivity for both public and private users while supporting essential operational and emergency functions.

Public access to the Institute will be primarily provided at Level 1 (ground floor), where visitors enter through a designated foyer leading to the reception area. Additional entry points include the retail outlet and café entrances, both of which allow direct engagement with external users while maintaining clear distinctions between communal and restricted spaces. By ensuring multiple access points, the Institute would foster seamless interaction between research-focused areas and publicly accessible facilities.

All access points, including lifts, would operate under a regulated system managed via smart access keys, issued exclusively to registered occupants. These keys would function within a hierarchical security clearance framework, ensuring restricted access to specialised areas such as the Algae Research Unit and Technical Laboratories, requiring enhanced authorisation levels. This system strengthens security while facilitating efficient circulation for authorised personnel.

Each of the 11 access cores also serves as an external fire escape, meeting stringent safety and regulatory requirements. Additionally, two service cores, one located within each deck cluster, are designated as fire cores reserved exclusively for emergency response teams. Equipped with dry risers, these cores would provide essential infrastructure for firefighting operations, enabling rapid response in critical situations. The integration of dedicated fire cores reinforces the Institute's commitment to safety, preparedness, and compliance with fire protection standards.

Service access to the Institute will be managed via the main entrance building, situated off Portwall Lane. Goods and stock deliveries follow a structured logistical framework, with large service core lifts transporting items to the upper decks, while materials destined for storage would be transferred to the basement plant and storage areas. The principal goods store, adjacent to the service entrance, incorporates secure storage facilities compliant with Control of Substances Hazardous to Health (COSHH) Regulations, ensuring the safe handling of hazardous materials (Statutory Instruments 2002 No. 2677).

To optimise workflow efficiency and minimise disruption, service goods transportation to the upper decks will be predominantly scheduled during off-peak hours. This approach reduces congestion, streamlines logistical operations, and maintains an uninterrupted experience for building occupants, while supporting the Institute's research and commercial activities.

Plate 31

Plate 39. Edge rail with braille signage.

4.3.6 Inclusive design

The Disability Discrimination Act (DDA) of 1995 has a significant influence on the design and development of the built environment, requiring comprehensive measures to enhance accessibility and inclusivity. Additionally, Part M of the Building Regulations and British Standard 8300 provide critical guidance on the implementation of accessible facilities. In accordance with these regulations, the Institute of Urban Cultivation is designed to ensure equitable access for all individuals, regardless of physical ability.

To support mobility-impaired occupants, the project includes DDA-compliant lifts and Part M-compliant stair cores, facilitating access to all accommodation and cultivation decks. Furthermore, Level 02 prioritises accommodation for individuals with mobility challenges, ensuring their needs are met through enhanced provisions.

Beyond physical accessibility, the Institute is committed to fostering an inclusive environment through the integration of assistive features for visually impaired individuals. All signage within the facility will be presented in Braille, enabling clear and independent navigation. Additionally, an edge marker rail will be installed along the boundaries of each deck, assisting visually impaired occupants in identifying their spatial position with ease. These measures collectively contribute to a fully inclusive and user-friendly design, reinforcing the Institute's commitment to accessibility and equal participation in its spaces.

5.0 Technical strategies

5.1 Environmental Strategies

The Institute of Urban Cultivation integrates a comprehensive environmental strategy that prioritises sustainability, air quality improvement, noise reduction, and sustainable transport solutions. Through innovative land use, cultivation practices, and ecological remediation, the project aims to enhance urban biodiversity, mitigate pollution, and support a healthier built environment, while fostering long-term environmental resilience and regeneration (Gunawardena, 2008).

5.1.1 Sustainability Statement

Land and building use contribution

The proposed land use of the building is best characterised as an institutional research facility, with a significant proportion of its functions dedicated to cultivation practices conducted above the ground plane. As part of the broader scheme, the ground-level area is also designated for cultivation purposes, further integrating the facility within its surrounding environment.

At present, the ground surface poses a contamination risk due to previous land use activities. To enable successful cultivation, appropriate remedial strategies must be implemented, as outlined in Chapter 7.0. Addressing these environmental concerns is critical to ensuring the viability of the site for sustainable agricultural and ecological development (Gunawardena, 2008).

Once these remediation measures have been effectively undertaken, the cultivated urban park will significantly enhance and expand the existing greenery within the site. Through the establishment of this green mega-structure, the Institute aims to contribute to the ecological improvement of the urban landscape, reinforcing its commitment to environmental restoration and sustainable land use.

Air quality improvements

The cultivated urban park strategy seeks to fully pedestrianise Redcliffe Way, thereby significantly reducing vehicular traffic in the vicinity of the Institute building (i.e., reducing sources). By minimising road traffic, the scheme promotes a quieter, more sustainable urban environment, aligning with broader objectives of environmental enhancement and pedestrian accessibility.

As the ground plane will predominantly feature cultivated urban greenery, it is anticipated that air quality in the area will improve substantially in comparison to current conditions. The extensive planting within the park will serve as a natural air filter, mitigating pollutants and fostering a healthier atmospheric environment through the phytoremediation function of vegetation (Lambers, et al., 1998).

In addition to the benefits provided by urban greenery, the Institute will incorporate CO_2 collectors designed to extract carbon dioxide from the atmosphere, utilising it as a nutrient source for algae cultivation. This process will contribute to air purification, making the atmosphere within and around the Institute healthier and more conducive to human well-being than typical urban localities in Bristol.

Noise attenuation

The operational functions of the Institute are not anticipated to generate any significant adverse effects in terms of noise pollution. The facility is designed to ensure minimal acoustic disruption to its surrounding environment, supporting both research activities and community integration without compromising ambient sound levels.

The primary source of noise production within the Institute are the algae energy generators, strategically positioned beneath the surface at basement level. This subterranean placement serves to mitigate potential sound emissions, ensuring that operational vibrations and mechanical noise remain contained within designated plant areas. By implementing this design approach, the Institute effectively minimises its acoustic footprint, aligning with sustainability principles and best practices in environmental noise management.

Transport integration

The Institute is integrated within a mega-structural system that supports a Light Rail Transit (LRT) network, reinforcing its commitment to sustainable urban mobility. In addition to this strategic positioning, the facility is situated just a minute's walk from Temple Meads Station, a major transport hub that is well served by bus routes providing connections to key destinations across the city and beyond.

The Institute's location also ensures proximity to extensive cycling and pedestrian infrastructure, with numerous cycle paths and footpaths converging in the area due to the presence of Temple Meads Station. Cycling is actively encouraged within the scheme through the provision of dedicated cycle racks and parking, promoting environmentally sustainable commuting options for occupants and visitors.

Given the Institute's strong integration with public transport networks and its overarching philosophy of fostering a greener urban environment, no parking spaces will be allocated within the facility for its occupants. Instead, those requiring parking will need to utilise nearby multi-storey car parks situated within the vicinity. While permanent staff may request dedicated parking spaces, such provisions will generally be discouraged in line with the project's sustainability goals.

Furthermore, the cultivated urban park along Redcliffe Way will be fully pedestrianised, reinforcing the commitment to reducing vehicular presence in the immediate environment. Only a limited number of access routes will be preserved for servicing vehicles, ensuring essential operational functions while prioritising pedestrian accessibility and environmental quality. Through this approach, the Institute seeks to enhance urban sustainability, minimise carbon emissions, and contribute to a more walkable and cyclist-friendly cityscape.

Environmental Impact Assessment (EIA)

Given the scale of the development, which is defined as a mega-structural strategy, an Environmental Impact Assessment (EIA) is a mandatory requirement for this project. The EIA will provide a comprehensive evaluation of all relevant environmental factors, including the aspects outlined in previous sections, with a particular focus on sustainability and ecological enhancement.

A key component of this assessment will be an extensive carbon economics study conducted by a specialist consultant. This study will critically analyse the project's overall carbon footprint, ensuring that mitigation strategies align with best practices in environmental stewardship. By incorporating detailed quantitative and qualitative assessments, the EIA will contribute to informed decision-making and regulatory compliance.

It is anticipated that the Institute, along with the broader green megastructure, will significantly improve the existing urban environment. By fostering sustainable land use and promoting biodiversity, the project aims to create a more favourable ecological setting compared to current conditions. Additionally, the reintroduction of cultivation within this part of the city is expected to generate long-term environmental benefits by supporting the development of an urban ecology with an increasingly diverse biological presence.

Through these measures, the Institute seeks to enhance ecological resilience and contribute to a more sustainable urban landscape, reinforcing its commitment to environmental responsibility and progressive urban regeneration (Gunawardena, 2008).

5.1.2 Building Services strategies

The building service strategies of the Institute are predominantly driven by a renewable energy source derived from algae cultivation. Algae, as a biofuel crop, has been selected due to its exceptional efficiency in energy production and its adaptability to urban environments. Unlike conventional biofuel sources, algae can be cultivated within controlled settings, making it a viable and sustainable option for integration into the Institute's energy framework.

Beyond its role in biofuel generation, algae growth contributes significantly to environmental sustainability. During its cultivation, algae absorbs and fixes substantial quantities of atmospheric CO_2, thereby reducing carbon emissions. Additionally, algae functions as a natural decontaminant, actively removing pollutants from the urban environment and converting harmful gases into organic compounds. This dual capability positions algae as a key component in the Institute's broader ecological strategy, supporting both energy production and environmental remediation.

Recent research has explored the potential of algae-based biofuels as a scalable and efficient energy source. For instance, a study highlighted by the BBC examined how algae can be harnessed to create sustainable fuel alternatives, reinforcing its viability as a renewable energy solution (Henley, 2008). By integrating algae cultivation into the Institute's operational framework, the project aligns with contemporary advancements in green energy and contributes to the ongoing transition towards carbon-neutral urban systems.

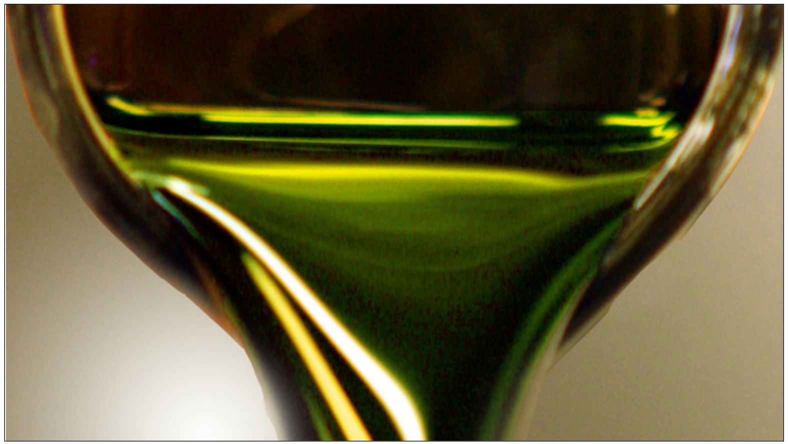


Plate 40. Algae biofuel – 'green gold'.

Algae-based biofuel: sustainable energy for urban cultivation

The cultivation and utilisation of algae for biofuel production present a promising alternative to fossil fuels. Given its rapid growth rate and ability to function efficiently in controlled environments, algae demonstrate significant potential as a sustainable energy source. The following examines the cultivation, harvesting, and energy production processes associated with algae biofuel, alongside its environmental benefits and scalability in urban settings (Patil, et al., 2008).

Algae cultivation and growth conditions

Algae share similar growth requirements with conventional crops such as tomatoes, thriving under controlled conditions with appropriate levels of warmth, light, carbon dioxide, and nutrients. As one of the fastest-replicating plants, algae biomass can double within 24 hours, making it an efficient source of organic material for biofuel production (Henley, 2008; Chisti, 2007; Patil, et al., 2008).

One of the critical challenges in algae cultivation is managing the clogging effect within production systems. The patented internal cleaning system developed by Algae-Link for example, enables continuous harvesting, ensuring operational efficiency and uninterrupted biofuel extraction (Henley, 2008). By maintaining optimal growth conditions and refining harvesting mechanisms, algae production can as a result support large-scale energy demand (Chisti, 2007).

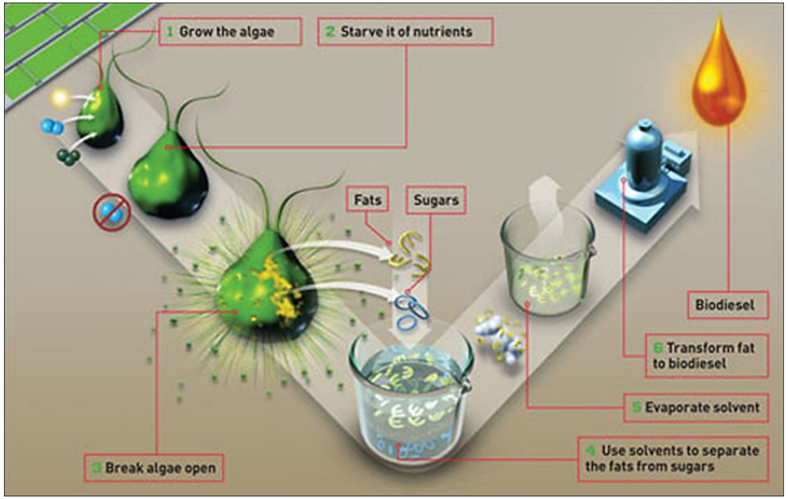


Plate 41. Algae biofuel processing diagram.

Processing and applications of algae biofuel

Once harvested, algae cells undergo a refining process to extract their constituent components, separating green mass for use in aquaculture and isolating vegetable oils for fuel production. While biofuel extraction is an established scientific practice, proprietary techniques ensure optimal yield from algae (Chisti, 2007).

Scalability remains a key concern for widespread implementation. Critics argue that extensive land allocation is required to meet global fuel demands. However, algae cultivation in vertical tube systems enables production on otherwise unutilised land, such as brownfield sites and desert regions. Ongoing projects in northern China demonstrate the feasibility of large-scale algae farming in non-arable environments, reinforcing its potential as an alternative energy source.

HOW GREEN ARE BIOFUELS?

Biofuels are getting a bad rap as stories of rising food prices and shortages fill the news. But the environmental, energy and land use impacts of the crops used to make the fuels vary dramatically. Current fuel sources – corn, soybeans and canola – are more harmful than alternatives that are under development.

FUEL SOURCES

CROP	USED TO PRODUCE	GREENHOUSE GAS EMISSIONS* Kilograms of carbon dioxide created per mega joule of energy produced	USE OF RESOURCES DURING GROWING, HARVESTING AND REFINING OF FUEL				PERCENT OF EXISTING U.S. CROP LAND NEEDED TO PRODUCE ENOUGH FUEL TO MEET HALF OF U.S. DEMAND	PROS AND CONS
			WATER	FERTILIZER	PESTICIDE	ENERGY		
Corn	Ethanol	81-85	high	high	high	high	157%-262%	Technology ready and relatively cheap, reduces food supply
Sugar cane	Ethanol	4-12	high	high	med	med	46-57	Technology ready, limited as to where will grow
Switch grass	Ethanol	-24	med-low	low	low	low	60-108	Won't compete with food crops, technology not ready
Wood residue	Ethanol, biodiesel	N/A	med	low	low	low	150-250	Uses timber waste and other debris, technology not fully ready
Soybeans	Biodiesel	49	high	low-med	med	med-low	180-240	Technology ready, reduces food supply
Rapeseed, canola	Biodiesel	37	high	med	med	med-low	30	Technology ready, reduces food supply
Algae	Biodiesel	-183	med	low	low	high	1-2	Potential for huge production levels, technology not ready

* Emissions produced during the growing, harvesting, refining and burning of fuel. Gasoline is 94, diesel is 83.

Source: Martha Groom, University of Washington; Elizabeth Gray, The Nature Conservancy; Patricia Townsend, University of Washington; as published in Conservation Biology SEATTLE P-I

Environmental benefits

Algae functions as an effective carbon capture agent, with approximately 1 kg capturing 1.83 kg of atmospheric CO_2 during growth (Chisti, 2007). This characteristic makes it particularly advantageous for deployment near industrial sites, such as power stations and processing plants, where it can mitigate emissions (Benemann, 1997).

Plate 42. Algae being cultivated under active conditions.

Additionally, algae biofuel supports broader environmental sustainability initiatives. Integrated within urban cultivation projects, its energy production processes align with principles of carbon offsetting, ultimately contributing to the goal of achieving carbon neutrality. While initial implementation may not immediately result in a carbon-neutral status, ongoing research and refinement of cultivation strategies will facilitate progressive improvements.

Development and prospects

Expansion efforts in greenhouse and open-air production sites in Europe and China signal increasing investment in algae biofuel as a viable renewable energy source. As the Institute of Urban Cultivation develops its servicing strategies, algae will serve as a primary component in powering both habitation and food cultivation, forming part of an interconnected urban ecosystem.

Through continued advancements in algae-based biofuel technology, the integration of sustainable cultivation methods, and the refinement of carbon mitigation strategies, urban environments can transition towards self-sustaining energy solutions. The establishment of algae biofuel as a mainstream renewable energy source has the potential to significantly reduce dependence on conventional fossil fuels, while fostering resilient urban ecological systems.

Plate 43. Residual green matter used as fertiliser and fish food.

Complementary strategies

The building service strategies of the Institute are primarily centred around renewable energy, with algae biofuel serving as the principal source. This approach integrates sustainable practices to ensure efficient energy production while minimising environmental impact. In addition to algae-based on-site energy generation, the Institute would employ a range of complementary strategies designed to enhance sustainability and operational efficiency.

One such strategy is the incorporation of solar panels mounted on deck roofs, which provide supplementary power to active mechanisms involved in both algae cultivation and broader cultivation practices. These panels, contribute to the overall energy mix by harnessing solar radiation, thereby reducing reliance on conventional energy sources and supporting the Institute's commitment to renewables.

Furthermore, the project takes advantage of the extensive ground plane coverage, incorporating a thermal heat pump system embedded beneath the site. This system enhances heating and cooling efficiency by utilising geothermal energy, which ensures stable indoor thermal conditions while reducing dependency on fossil fuels. The thermal heat pump works by transferring heat from the ground to the building during colder periods and dissipating excess heat back into the ground during warmer periods, thereby maintaining optimal internal environments and controlled conditions in laboratories.

The integration of these strategies within the overall design framework reflects the Institute's commitment to environmental sustainability and energy resilience. By combining on-site algae-based energy production, solar power generation, and geothermal heat exchange, the project establishes a comprehensive and multi-layered approach to sustainable building services.

Additionally, the project adopts a holistic view of energy efficiency, ensuring that renewable energy solutions are seamlessly embedded within the architectural and operational framework. The synergies between the various energy systems foster a dynamic and adaptive response to changing environmental conditions, thereby enhancing long-term sustainability.

Through these measures (with functional components expressed in architectural form and detailing), the Institute positions itself at the forefront of sustainable design, demonstrating the viability of integrating multiple renewable energy systems within a cohesive architectural framework. The strategic implementation of algae-based energy production, solar power, and geothermal heat transfer exemplifies a forward-thinking approach that prioritises both environmental responsibility and operational efficiency. This commitment to sustainability would serve as a model for future developments, reinforcing the need for innovative and integrated energy strategies to be expressed in their contemporary architectural manifestations.

Plate 37

Plate 39

5.2 Materials strategy

5.2.1 Steel as a primary construction material

Steel, as a construction material, possesses exceptional compressive and tensile properties, rendering it highly effective in demanding structural applications. It is as a result the material of choice for complex structural projects, including bridges and other large-scale infrastructural developments. Its inherent structural efficiency enables the achievement of extensive spans with minimal construction depth, thereby reducing structural mass and maximising usable space.

The primary constituent of steel, iron (Fe), is the most abundant element found on Earth. Moreover, steel is a sustainable resource, capable of being recycled indefinitely without any degradation in its properties or performance. Additionally, all steel construction components are manufactured off-site, cut to precise lengths, and often pre-drilled and fabricated to facilitate swift and straightforward assembly and erection. This pre-engineered approach significantly minimises material wastage on construction sites.

Embodied energy and carbon

Steel exhibits a significantly higher embodied energy value compared to most other construction materials, with a substantial portion of this energy attributed to the smelting process. However, recycled steel presents a more sustainable alternative, requiring only one-third of the embodied energy of virgin steel. Given that structural components are designed based on standardised dimensions, the most sustainable approach is to prioritise the use of reusable structural members wherever feasible. Where such elements are unavailable, incorporating recycled steel components remains an effective strategy for reducing environmental impact while maintaining structural integrity.

Table 3. Relative material properties.

Material	**Energy (MJ/kg)**	**Carbon (kg CO_2/kg)**	**Density (kg/m³)**	**Source**
Concrete (general mix)	~1.1	~0.13 - 0.16	2300 - 2400	(Cole & Kernan, 1996)
Bricks (facing)	~8.2	~1.46	~1700	(Cole & Kernan, 1996)
Bricks (common)	~3.0	~0.22	~1700	(Cole & Kernan, 1996)
Concrete block (150mm)	~0.7	~0.08	~1900	(Cole & Kernan, 1996)
Steel (virgin)	~35.3	~2.75	7850	(Hammond & Jones, 2006)
Steel (recycled)	~9.5	~0.43	7850	(Hammond & Jones, 2006)
Timber (general)	~8.5	~0.46	480 - 720	(Gustavsson, et al., 2006)

Although steel possesses a significantly higher embodied energy value compared to other construction materials (see Table 3), it offers a range of advantages that effectively mitigate this initial impact. As outlined in the subsequent sections, these benefits contribute to steel's long-term sustainability, making it the most viable option, particularly in relation to the requirements of this design thesis.

Shop manufacture

Off-site manufacturing is a Modern Method of Construction (MMC) that offers numerous advantages over on-site construction. It significantly enhances safety, as many processes are fully or semi-automated, reducing the risks associated with manual labour. Factory-based production ensures precise, high-quality workmanship, resulting in reliable construction components with minimal defects. Additionally, shop-manufactured products can be easily standardised and rigorously tested, further improving their consistency and performance efficiency (Harrison, 2004; Egan, 1998).

Corrosion and fire protection coatings, particularly intumescent coatings for steelwork, are increasingly applied in factory settings rather than on-site. This approach enhances quality control by ensuring uniform coverage, minimising wastage from overspray, and reducing the time required for on-site application. By applying coatings during manufacturing, delays for subsequent trades on-site are mitigated, contributing to shorter project timelines (Harrison, 2004).

Furthermore, modern steel construction elements are produced using advanced, computerised equipment designed to minimise material wastage. Any steel waste generated during manufacturing, such as off-cuts or turnings, is fully recycled, reinforcing steel's role as a highly sustainable construction material (Hammond & Jones, 2006).

Recycling and reuse

Steel is the world's most extensively recycled material, with over 400 million tonnes repurposed annually, accounting for approximately 40% of global steel production (World Steel Association, 2008). It is entirely recyclable using existing technologies, retaining the same properties as virgin steel, which enables continuous reuse without any loss in performance or quality (Harrison, 2004).

The recycling process for steel is sustainable, requiring no primary raw materials, generating minimal waste, and consuming only about one-third of the energy needed to produce steel from virgin resources. The intrinsic value of steel is reflected in the economic worth of scrap, which remains sufficiently high to ensure efficient recovery and recycling. All steel contains a proportion of recycled content, ranging from 10 to 100%. Recent research conducted by the Steel Construction Institute has determined that on average, 84% of construction steel in the United Kingdom is recycled, with an additional 10% reused (Steel Construction Institute, 2006).

There exists substantial potential to enhance the reuse of structural steel, and ongoing initiatives within the sector aim to advance and facilitate this practice. For example, the University of Bath's BRE unit is actively investigating reuse strategies. The effectiveness of the steel construction sector in supporting such efforts is reinforced by the standardisation of components and connections.

Steel can be repurposed at both the product and building scales. At the product level, it can be reused in the form of structural members, including hollow sections, as well as lighter gauge elements such as purlins, rails, and channels. At the building level, particularly concerning this design thesis, entire structural modules could be reused with only minor modifications. The process of product reuse is relatively straightforward, typically involving the inspection of used sections to verify their dimensional accuracy and structural integrity. These sections are then shot-blasted or sand-blasted to remove coatings before undergoing re-fabrication, which often entails cutting beams and columns to required lengths.

On a larger scale, complete steel buildings can be dismantled and reused. A notable example is the British Pavilion at the 1993 Seville Expo, an innovative and energy-efficient steel structure designed for post-event reuse. Similarly, the mega-structural system proposed in this design thesis embodies this principle, presenting itself as an adaptable urban strategy that can be disassembled and re-erected with only minor site-specific modifications.

Maintenance and durability

Steel construction products incorporate a variety of corrosion protection systems to enhance durability and minimise maintenance requirements—an essential consideration given the high-rise nature of the design. Weathering steels, which are high-strength, low-alloy, and weldable, exhibit excellent resistance to atmospheric corrosion without necessitating additional protective coatings. These steels typically contain up to 2.5% alloying elements, such as chromium, copper, and nickel (Harrison, 2004). When exposed to air, a protective rust patina develops on the steel's surface, significantly slowing the corrosion process. After two to five years, corrosion is largely mitigated. These steels are often referred to as pre-rusted steels, and the megastructural components of this design will be fabricated from such a grade of weathering steel.

The suspended structural decks of the building function as three-dimensional trusses or beams, requiring high-performance structural specifications. To meet these demands, the design strategy incorporates high-strength cold-rolled sections, protected by durable and cost-effective coatings. A selection of generic protective coatings is available for steel members, including air-drying paints such as alkyds, one-pack chemical-resistant paints like acrylated rubbers, and two-pack chemical-resistant coatings such as epoxy and urethane. These coatings serve a dual purpose: providing protection against corrosion, and acting as intumescent layers to enhance fire resistance.

5.2.2 Timber as a secondary construction material

In the evolving context of sustainable architecture, timber has reasserted itself as a vital material for low-impact, environmentally conscious construction. As a secondary construction material in this project, timber is utilised for cladding, internal flooring, decking, and secondary structural applications. All timber will be locally sourced, supporting carbon reduction strategies and circular economy principles. This section critically evaluates timber's performance through key sustainability metrics: embodied energy and carbon, sustainable sourcing, recyclability, and durability in weathering applications.

Embodied energy and carbon

Timber is widely acknowledged for its low embodied energy and carbon footprint when compared to more industrial materials like steel and concrete. Embodied energy refers to the total energy input for extraction, processing, manufacturing, and transportation. Softwood has an embodied energy of approximately 0.5 MJ/kg, which contrasts significantly with structural steel (32 MJ/kg), and reinforced concrete (up to 1.2 MJ/kg), (Hammond & Jones, 2008).

Beyond low energy uptake, timber stores carbon absorbed during a tree's lifespan. This sequestration remains locked in the wood until it is decomposed or burned, effectively delaying atmospheric CO_2 emissions. Studies compiled by the Building Research Establishment (BRE) support the claim that substituting timber for higher carbon materials reduces overall greenhouse gas emissions (Purdy, 2003). As such, timber contributes both to operational efficiency and long-term carbon management within construction.

Sustainable sourcing in the UK

The UK has strong commitments to sustainable forestry practices. Much of the available commercial timber is certified under the Forest Stewardship Council (FSC) and the UK Woodland Assurance Standard (UKWAS), ensuring legal, ethical, and sustainable harvesting methods. The Forestry Commission (2006) reported that over a million hectares of UK woodland are sustainably managed, with efforts to balance commercial yield and biodiversity conservation.

Sourcing timber locally not only supports sustainable land management but also reduces the environmental impact of transportation. Timber harvested and processed within regional supply chains contributes fewer transport-related emissions compared to imported alternatives. This project prioritises locally milled softwoods such as larch and Douglas fir, both known for their durability and availability in the UK market (TRADA, 2005).

Recycling and reuse

Timber offers considerable potential for reuse and recycling, especially as a secondary construction material. Unlike materials requiring extensive reprocessing, such as steel or concrete, timber can often be repurposed with minimal alteration. The Building Research Establishment (2002) had emphasised that reclaimed timber products, particularly hardwood flooring and structural sections, can be reused with little compromise to their performance.

In guidance from the Steel Construction Institute and Waste & Resources Action Programme (WRAP), timber was consistently identified as a highly reusable material in the context of demolition and material recovery (WRAP, 2007). Reclaimed timber from interior applications (e.g., flooring, panelling) was also documented as retaining up to 90% of its usable volume, with minimal reprocessing.

End-of-life options for timber include reuse, re-manufacture into composite products, or energy recovery. For this project, timber components such as decking boards and cladding are designed for disassembly, promoting future reuse. Mechanical fixings and modular detailing ensure their lifecycle extends beyond initial application.

Maintenance and durability

Timber's response to weathering is a key consideration in its external use. Certain species, such as western red cedar and European larch, are naturally durable and require no chemical treatment to withstand the elements. When exposed, these timbers gradually develop a silvery-grey patina. This weathering process is aesthetic rather than structural and has long been valued in architectural traditions such as Scandinavian and Japanese timber design (Harris, 1993).

TRADA (2005) has identified larch and cedar as among the most effective species for cladding, offering 15–30 years of service life without coatings, when detailed and ventilated appropriately. In this project, naturally weathering timber is used on façades and external decks to minimise maintenance and chemical use. Internally, selected hardwoods offer abrasion resistance and aesthetic appeal for flooring, while remaining refinishable across decades. Appropriate detailing, such as raised fixings, end grain protection, and adequate ventilation, enhances longevity. Where untreated timber is exposed, the design accounts for run-off, capillary breaks, and replaceable elements, ensuring a durable and sustainable outcome.

5.2.3 Materials strategy summary

The material strategy for the project is formulated with careful consideration of the extensive demands imposed by the mega-structural system, including the significant spans that any applied material system must accommodate. Additionally, the projected service life expectation necessitates the selection of materials that ensure long-term durability and efficiency. The strategy therefore prioritises steel as it offers optimal efficiency in terms of primary structural performance, while maintaining durability and delivering extended service life. Timber, distinguished by its inherent stability and low embodied energy, is employed to address secondary structural requirements and cladding applications, thereby aligning with sustainability objectives while fulfilling the fundamental performance criteria of the design.

Plate 19

Plate 25

5.3 Structural strategy

5.3.1 Construction form and detail

The structural approach for this project conceptualises the Institute building as a sequence of cantilevered bridges, supported by megastructural piers or pylons. In addition to these primary supports, strategically positioned steel rod/cable ties and struts have been integrated at key junctions to enhance the efficiency of the structural system. This optimisation not only improves load distribution but also minimises the overall steel usage, contributing to a more resource-efficient and sustainable construction method.

5.3.2 Modular steel construction

Modular construction is a Modern Method of Construction (MMC) that enhances the advantages of off-site manufacturing, scaling up both efficiency and precision (Egan, 1998). Module units can be fully assembled in factory conditions with finishes, sanitary installations, and other essential fittings, allowing for swift and seamless placement on-site via crane. Consequently, all accommodation types, bathroom units, and select repetitive programme elements within the Institute of Urban Cultivation will be pre-assembled off-site, transported, and installed with minimal disruption.

The adoption of steel-based modular construction systems in this project offers significant benefits, particularly due to their flexibility and lightweight properties. These attributes align well with the project's structural and environmental objectives. The key motivations for incorporating modular construction include:

- Accelerated on-site construction: Programme durations are considerably shortened.
- Minimal disruption to surrounding areas: This approach mitigates the impact on adjacent infrastructure, including roads, Temple Meads Station, offices, and nearby hotels.
- Integration of complex components: Steel modular construction accommodates elements with high servicing requirements and intricate technical detailing. Off-site pre-compliance trials ensure precision, particularly necessary for specialised systems such as hydroponic racking.
- Optimisation through repetition: Shop manufacturing supports economies of scale for regular, repeated units, improving cost-effectiveness.
- Adherence to planning regulations: Noise control, restricted delivery times, and other urban planning constraints are more effectively managed through modular construction, making it well-suited for dense urban environments.
- Enhanced quality control: Pre-installation checks and precise detailing ensure consistency, meeting the project’s rigorous design standards and construction tolerances.

- Streamlined procurement processes: A modular approach facilitates a design, manufacture, and build service, allowing a single contractor to oversee steel sourcing. Steel procurement accordingly follows a sustainable priority hierarchy:
    1. Reusable steel
    2. Recycled steel
    3. Virgin steel

This strategy reinforces the project's commitment to sustainability, efficiency, and adaptability, offering an innovative approach to contemporary construction challenges.

5.3.3 Assembly strategy

The construction of the mega-structural core footings represents the initial phase of on-site development. Designed to support the full structural loads of a core tower of maximum expected height, including all anticipated dead and live loads, these footings can be constructed using an efficient modular construction methodology. To achieve this, the majority will adopt a modular precast concrete approach, facilitating both precision and consistency in their fabrication. These precast components will be securely integrated with insitu footings, ensuring structural continuity and load distribution while optimising construction efficiency. This strategy not only enhances durability and performance but also streamlines on-site assembly, reducing overall construction time and logistical complexity.

The mega-structural modules, or structural core bays, will be shop-manufactured, transported, and installed via crane to form the project's structural cores. These provide the framework for subsequent accommodation decks, assembled using their corresponding bay units. Inspired by bridge construction, structural bays will be incrementally added to form a deck, with decks systematically connected to complete the structure. This modular approach enables rapid, precise assembly while minimising on-site risks, ensuring efficiency in construction. By streamlining fabrication and installation, the method enhances overall structural integrity and build quality.

Plate 44. Sydney Harbour Bridge being constructed, 1930.

Plate 7a

Plate 8

6.0 Regulatory compliance

6.1 Planning constraints to be addressed

6.1.1 Supplementary Planning Document (SPD) 03

In accordance with the findings of the traffic flow survey, which indicate a diminished role for vehicular traffic along Redcliffe Way, SPD 03 recommends its downgrading (Bristol City Council, 2006). This design thesis acknowledges this recommendation and advances a proposal for a fully pedestrianised Redcliffe Way, incorporating a cultivated urban park with superimposed pedestrian walkways, while preserving limited vehicular access solely for servicing purposes.

SPD 03 emphasises the importance of maintaining a significant view of St Mary Redcliffe from the Temple Gate junction (see Plate 9, p. 65). This design thesis adheres to this directive, establishing it as a fundamental design constraint that has directly influenced the geometry of the deck structure and the spatial arrangement of deck units, thereby shaping the overall composition of the building cluster.

While aligning with certain recommendations of SPD 03, this scheme diverges from its proposed strategy of infilling Redcliffe Way with additional buildings. Instead, it presents an alternative approach that aligns more closely with SPD 05 on *Sustainable Building Design and Construction*, which advocates for the integration of renewable energy sources as a crucial aspect of contemporary development. Furthermore, this argument is supported by overarching Government policies promoting sustainable development, renewable energy production, and urban food cultivation. The rationale is reinforced by the perspectives of the UK Chief Scientist, Professor John Beddington (McGourty, 2009), as well as national and regional policy frameworks outlined in the Regional Spatial Strategy (RSS), thereby substantiating the robustness and viability of the proposal.

6.1.2 Supplementary Planning Document (SPD) 01

The height of the proposed mega-structural system and the Institute must be justified in accordance with SPD 01 (2005). Bristol City Council defines a tall building as exceeding nine storeys, placing both the mega-structural system and the Institute at the threshold of this designation. SPD 01 stipulates that if a substantial portion of a building's mass exceeds 27 metres in height, the proposal must undergo an assessment against the established criteria for tall buildings. As the upper level of the mega-structure slightly surpasses this threshold, the planning application will necessitate compliance with SPD 01's assessment requirements. The key arguments for addressing this evaluation are explored in the urban strategy section of Chapter 4.0, which illustrates how the proposed mega-structural composition integrates harmoniously with the existing architectural context to the north of Redcliffe, avoiding any overbearing contrasts in scale.

6.2 Flood risk management

The Redcliffe Way site lies beyond the flood protection zones highlighted by the Environment Agency (see Plate 45). A flood risk assessment for the Institute is therefore not applicable.

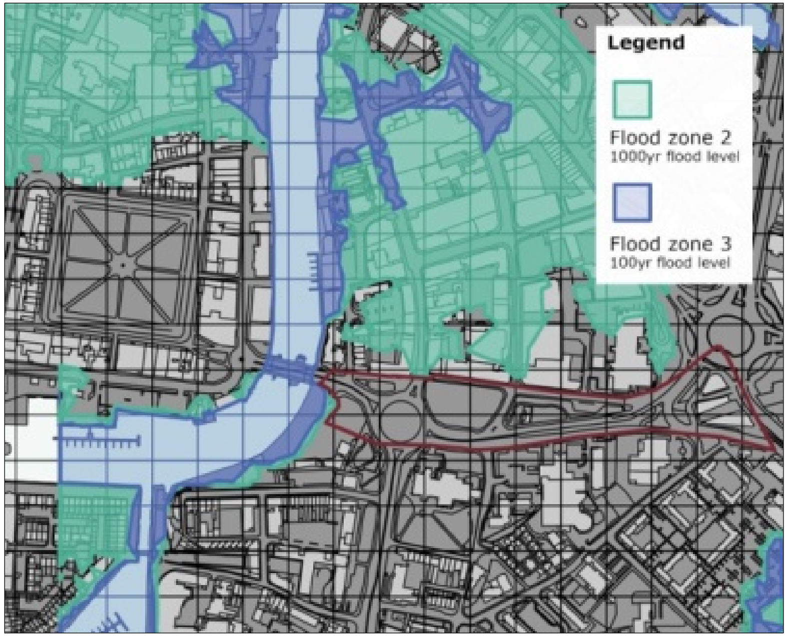


Plate 45. Environment Agency flood zones for the Redcliffe area of Bristol.

6.3 Waste management

The Institute's refuse disposal strategy will utilise Bristol City Council's segregated recycling services. Waste collection will occur via the designated service entrance off Portwall Lane, ensuring efficient management and alignment with municipal waste protocols to support sustainable waste handling and environmental objectives.

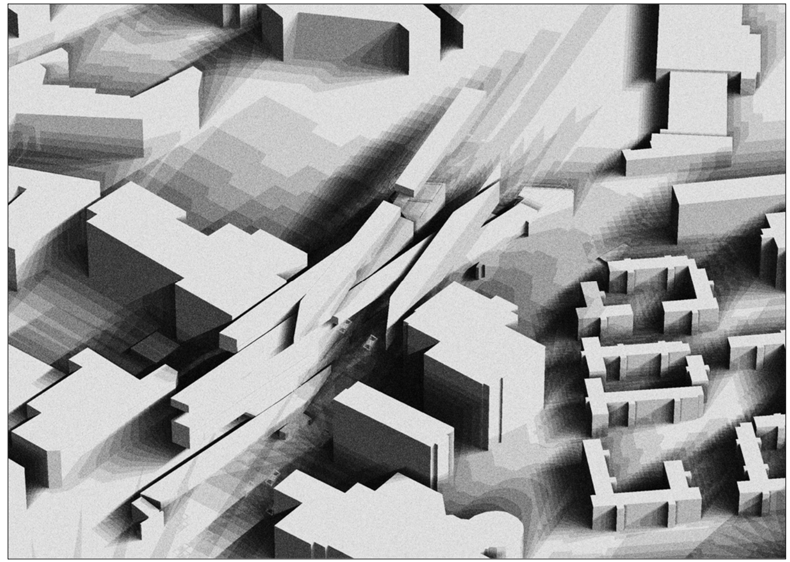


Plate 46. Shadow simulation in Ecotect.

6.4 Daylight impact assessment

The initial design strategy for the mega-structural system and the Institute sought to retain Portwall Lane as a five-metre-wide street, reflecting the medieval character of an inner city-wall street (Gunawardena, 2008). However, shadow analysis (see Plate 46) revealed that this arrangement would result in excessive overshadowing of the adjacent building to the north. Consequently, the revised scheme proposal widens the road to 10 metres to mitigate this impact. Despite this adjustment, some overshadowing will persist during winter months. While unavoidable without compromising the Institute's programmatic requirements, this condition introduces a project risk, potentially necessitating legal compensation measures.

6.5 Fire strategy

The fire safety provisions outlined herein comply with Part B, Volume 2 of the Building Regulations 2010 (DCLG, 2007), which govern buildings other than dwelling houses.

The Institute of Urban Cultivation is designed to accommodate a maximum residential occupancy of 250 persons and will be served by eleven access cores, all integrated within the mega-structural system. Each core is capable of facilitating the safe evacuation of up to 23 occupants in the event of full capacity. These access cores function as external fire escapes, with their steel members treated with intumescent coatings to provide fire resistance. Additionally, two dedicated service cores, located within each deck cluster, serve as 120-minute fire cores for exclusive use by fire services, incorporating both dry and wet risers. Upon activation of the fire alarm, all lifts within the affected fire zone(s) will automatically shut down, triggering a pressurised sprinkler system to mitigate the risk of fire spread. Maximum escape distances on each deck have been restricted to 18 metres through the strategic placement of two escape cores at either end of any deck, thereby ensuring that evacuation can be completed within the prescribed 2.5-minute threshold.

The building's façade on the northern elevation maintains a substantial separation of no less than 14 metres from the adjacent structure. However, the two island buildings present a closer proximity to the Institute's facades, with the ninth level extending over their rooftops. To address the associated fire risks, the underside of the ninth-level deck will be coated with an intumescent layer, providing one hour of fire resistance against flame propagation, while structural elements will be fire-cased to preserve their integrity. Furthermore, external fire detectors will be installed beneath this deck to activate in response to fire incidents within the island buildings. On the southern deck cluster, where the structure adjoins an existing building, the steel framework will similarly be treated with intumescent paint to prevent the surface spread of flames. Detailed zoning of façades and internal fire protection measures are comprehensively addressed within the Fire Engineers report.

Historically, fire safety approvals necessitated a Fire Certificate issued by the relevant Fire Authority. However, under the Regulatory Reform (Fire Safety) Order (RRO) of 2005, responsibility for fire safety management has been transferred to the building owner or client. As part of the Institute's fire management plan, designated escape routes and assembly points will be established to ensure compliance with regulatory standards and safeguard occupant safety.

6.6 Public Utilities and services

Water and Sewerage

A new subterranean water and sewerage line will be integrated along the mega-structural course, ensuring service provision for all associated functions of the structure. The Institute will utilise this infrastructure for its operational needs.

Water drainage will be directed to a basement-level recycling plant, with residual discharge routed to a soakage pit in the southwest of the site, within the cultivated urban park. Rainwater harvesting will be facilitated through collectors installed on each deck's roof, reducing dependence on mains supply where feasible while enhancing sustainability and efficient resource management.

Additionally, greywater processing plants on Levels 3, 4, and 5 will support water efficiency by supplying treated greywater for WC use. Detailed schematics outlining system integration and operational specifications will be included in the Mechanical Engineer's report.

Electricity (energy demand)

The Institute will maintain dual connections to the grid, enabling both consumption and surplus energy contribution via a dedicated substation. The primary source of electricity will be an algae fuel generator housed within the basement chain of the Institute. Any excess energy produced will be fed back into the grid under an agreement with the energy service provider. Detailed specifications will be outlined in the Mechanical and Electrical Engineer's report.

Telecommunications

The Institute will be integrated into the existing hardwired infrastructure, including fibre optic cabling, to ensure stable, high-speed communication. This connectivity will support essential operational needs, such as secure networking, efficient data transmission, and access to digital resources. Designed for adaptability, the system will accommodate future technological advancements while redundancy measures ensure service continuity. Detailed schematics, including connection points and technical specifications, will be provided in the Mechanical and Electrical Engineer's report, ensuring comprehensive planning and implementation.

7.0 Site works and landscaping

7.1 Addressing site contamination

During the Second World War, the Redcliffe area sustained significant damage due to bombing raids. It is believed that many of the resulting bomb craters were subsequently filled with building debris (Gunawardena, 2005). As a consequence of this practice, it is thought that heavy metals (particularly lead), were introduced into the local soil strata at unprecedented concentrations. The presence of lead in building debris can often be attributed to materials such as lead flashing and lead-based paints. Furthermore, industrial activity, notably glassworks operations during the twentieth century, is also suspected of having contributed additional contaminants to the extensive soil strata found across Redcliffe.

Contaminated soil presents a significant challenge for any endeavour involving productive cultivation. Certain heavy metals can interfere with the cation exchange mechanisms of various crops, leading to their premature deterioration (Lambers, et al., 1998; Alloway, 1995). In order to facilitate successful cultivation on Redcliffe Way (the site of the proposed urban park), a comprehensive programme of remedial decontamination measures will be required.

In accordance with Environment Agency guidance, a typical decontamination process comprises three key stages. The first stage involves conducting a Risk Assessment of the entire site. This evaluation aims to identify the presence of harmful concentrations of contaminants and determine their specific nature. Should the assessment confirm unacceptable contamination levels, remedial interventions must be undertaken before commencing any cultivation programme.

The second stage, known as the Options Appraisal, is designed to identify the most suitable remedial measures. This phase establishes the optimal remediation approach, or combination of approaches, for addressing all pollutant linkages that pose an unacceptable risk. The Environment Agency's primary considerations at this stage include (Environment Agency, 2007):

- Ensuring that the remediation criteria protect controlled waters;
- Selecting appropriate remediation methods for each identified pollutant;
- Confirming that the Remediation Strategy addresses all relevant pollutant linkages;

- Assessing the requirement for waste management licences, environmental permits, and discharge consents at an early stage of planning.

One preferred remedial approach in relation to this design thesis is the adoption of phytoremediation strategies. Phytoremediation refers to the use of plants to mitigate environmental contamination without resorting to excavation or off-site disposal of polluted materials. This method is particularly advantageous in minimising disturbance to existing biodiversity within the subsoil strata, during the decontamination process (Environment Agency, 2007).

Various plant species have been identified as effective agents for the removal of certain heavy metals. Examples include creosote plants and specific algae varieties, which have the ability to accumulate high concentrations of scavenged metals within their nonessential tissues. This characteristic allows for continuous treatment, thereby reducing the need for repeated cycles of planting and harvesting entire plants to achieve complete decontamination of a given area.

The third and final stage of decontamination pertains to the Implementation of the selected remedial measures. The principal objectives of this phase are to ensure that the remediation works achieve the prescribed environmental standards without inflicting unintended harm, while simultaneously maintaining an accurate and permanent record of the undertaken actions.

For the purposes of this thesis, a Phytoremediation Strategy encompassing a five-to-fifteen-year programme is proposed as the preferred option for decontamination. This strategy is designed to be implemented in phases, primarily to minimise disruption to pedestrian routes and maintain an accessible network of public footpaths throughout the duration of the project.

7.2 Landscape and crops

Following the successful decontamination process over a five-to-fifteen-year period, the network of paths will be permanently established, marking the shift from remediation to productive cultivation. The decontamination crops will be replaced with productive varieties, restoring the site's pastoral character and enhancing the historical presence of St Mary Redcliffe and its mega-structural system.

As cultivation reaches a sustainable level, designated areas will be allocated for public use, allowing local residents to access land allotments. This initiative fosters environmental stewardship, communal engagement, and shared agricultural responsibility.

The phased transition ensures long-term soil viability while encouraging continued land stewardship. This approach harmonises historical preservation with sustainable urban planning, creating a space where tradition and ecological responsibility coexist productively.

Plate 38

Plate 44

8.0 Project implementation

8.1 CDM Regulations and risk analysis

Under the Construction (Design and Management) Regulations, the CDM Coordinator must be appointed under standard conditions of engagement to undertake the following responsibilities (UK Government, 2007):

- Notify the Health and Safety Executive (HSE) at the outset of the project;
- Identify and assess risks, maintain the Risk Register, and ensure that the responsibility for managing such risks is allocated to those best equipped to do so;
- Assist in the coordination of information necessary for the pre-tender health and safety plan; and
- Compile the statutory Health and Safety File, which must ultimately be submitted to the client.

Risk identification and management within the project should be carried out in close collaboration with the CDM Coordinator, ensuring adherence to the following four essential and structured stages to effectively mitigate potential hazards, enhance safety protocols, and maintain compliance with regulatory requirements throughout the project's lifecycle (UK Government, 2007):

- Hazard Identification: determining potential sources of risk;
- Hazard Assessment: evaluating the likelihood and severity of unacceptable risks;
- Risk Estimation: forecasting the possible consequences, including their probability and magnitude; and
- Risk Evaluation: assessing whether the risk is deemed acceptable or unacceptable.

8.1.1 Factory production

A significant part of the building will be manufactured in a controlled factory environment (MMC), allowing workers to follow established procedural guidelines and policies that can be effectively implemented and monitored. This approach reduces health and safety risks compared to on-site construction. Additionally, factory-based production enhances quality assurance and enables rigorous testing to ensure components meet design specifications. By maintaining consistency and precision, this method supports safer, more reliable construction outcomes while optimizing efficiency.

Licensed mechanical cranes will be mostly used for on-site assembly. Working at height introduces safety risks that must be mitigated through proper equipment and management procedures, including safety harnesses and crane banksmen. Adherence to local council licensing guidelines ensures safe and efficient operations, maintaining compliance with regulatory standards while prioritising worker protection and operational effectiveness.

Once groundwork has commenced, designated areas for overhead construction must be securely fenced off to ensure public safety and prevent unauthorised access. As an essential precaution, during scheduled periods for overhead deck assembly, pedestrian movement should be redirected along the southern edge of the Redcliffe Way canyon to minimise risk. Furthermore, to reduce potential hazards and disruptions, all overhead work must be restricted to non-peak pedestrian flow periods, specifically avoiding the busiest times between 7:00 to 9:30 AM and 4:00 to 5:30 PM.

8.1.2 Public safety

During peak construction phases, the site manager will implement temporary restrictions on Portwall Lane to ensure public safety. These measures will be carried out in compliance with Bristol City Council guidelines and the relevant works licences, ensuring that safety protocols are upheld throughout the duration of the project.

Plate 47. Program 'type' (module), craned into place.

8.1.3 Site welfare facilities

Welfare facilities for the construction site, including temporary accommodation during the Institute's development, will be situated along the landscaped strip south of Portwall Lane, providing accessible and well-integrated provisions to support workers efficiently throughout the project (Health and Safety Executive (HSE), 2007).

8.1.4 Budgetary constraints and response

The Institute's primary funding source is expected to be the Carbon Trust, which receives government support for sustainable energy research. The Trust has committed £1 billion to advancing energy generation technologies, with an existing algae production initiative serving as a key precedent for this design thesis (Carbon Trust, 2008). This funding structure supports innovation, promotes sustainability, and contributes to renewable energy development.

8.1.5 Construction cost

The Institute's construction costs, including its mega-structural system, are reduced through a functionalist approach based on components and standardised types. Industrial finishing techniques facilitate large-scale infrastructural and spatial solutions, significantly lowering costs per unit, while maintaining efficiency and ensuring the effective implementation of structural and design requirements.

8.1.6 Project Programming

The mega-structural system is designed for phased implementation, ensuring an orderly and efficient construction approach. Each 40-metre bay will be developed sequentially, accompanied by individual business plans that align with broader project objectives. This structured approach allows for a controlled expansion, ensuring financial sustainability while optimizing construction efficiency. However, the Institute of Urban Cultivation will be delivered as a singular gateway project, serving as the critical catalyst for the subsequent implementation of the remaining mega-structural bays. By establishing this initial phase, the project sets a strong foundation for further development, fostering innovation and adaptability.

As with most construction programs, once groundwork is completed, the next phase involves assembling the structural cores, which in this case are represented by the mega-structural framework. This core framework provides primary structural integrity, ensuring stability for future expansions. Decks will be meticulously craned into place, progressing bay by bay to form the larger deck system. Additionally, decks will be positioned one at a time, facilitating the formation of an interconnected architectural cluster that defines the Institute's composition. This sequential assembly method ensures precision, enhances construction safety, and maintains structural coherence, reinforcing the Institute's overall functionality and design integrity.

9.0 Conclusion: Demonstration of a thesis in design

This thesis was undertaken with the firm conviction that it constitutes a work of social scientific research, rather than a positivist endeavour aimed at proving a predetermined hypothesis. Instead, the research has consistently sought to pose questions, functioning as a hypothesis-generating exercise. Over time, the narrative has undergone multiple refinements and layers of clarification, culminating in a project that presents a theoretical and practical argument.

The process of generating hypotheses inherently involved continuous questioning, leading to key decision-making milestones and ultimately establishing a coherent argument that integrates both theoretical discourse and design execution. Central to the project was an exploration of the relationship between manifestation and substance, as well as the interplay between the universal and the specific. The argument traverses the spectrum between universal ideals and detailed specificity; the essence (archetypal meaning) and its corresponding manifestation (aesthetic).

The mega-structural aspect of the design thesis thus evolved as a pursuit of the universal essence of habitation. It became a symbolic representation of the broader and more generic objectives inherent in habitation. As the design progressed, the mega-structure increasingly appeared to transcend authorship, taking on an autonomous quality; an urban chain reaction that could be shaped by multiple subsequent contributors. In its physical manifestation, the mega-structure seeks to refine itself into a more generic entity, minimal in its assumptions, yet open and adaptable enough to accommodate new interpretations.

Conversely, the design's detailed components engage directly with specificity, addressing the particular aspects of an agenda, namely urban cultivation. Throughout the design process, there was a continuous shift between the two polarities of universality and specificity, seeking to challenge and develop an urban cultivation ethic that evolves from its formative stages. The thesis argues that urban cultivation can be most effectively realised by redirecting the neutral framework within which it traditionally operates, adapting it by constant human interventions. Cultivation is thus encouraged to engage with urban dynamics, wherein their influences generate and affect tangible outcomes. In contrast to the mega-structure's generosity, detailed elements would therefore assert their demands with precision, at times, requiring strict adherence.

Due to its intent of engaging with contentious architectural issues, the thesis inevitably took on a polemical dimension. A polemical argument is constructed with the aim of provoking change, inviting diverse perspectives that generate new hypotheses, and refine the agenda in response to real-world implementation challenges. Thus, the completed project does not contend to be a definitive solution but rather a body of work designed to generate hypotheses. The questions it raises, both theoretical and practical, must be asked to shape the future trajectory of urbanism and architecture. In this respect, the thesis serves as a form of devil's advocate, interrogating existing paradigms to determine which elements of past and present architectural ideas should be preserved, and what specific attributes future manifestations should incorporate.

The acknowledgement of technology, particularly its role in controlling cultivation, and the conceptualisation of the mega-structure, required overcoming prevailing prejudices surrounding these themes. Throughout the year, some visiting critics expressed scepticism, dismissing aspects of the project based on aesthetic interpretations rather than substantive analysis. Many such preconceptions stem from associations with unsuccessful experiments from the 1960s. During the final critique for example, a principal critic voiced his opposition to what he perceived as an aesthetic reminiscent of high-tech architecture from that era. Without explicitly naming Peter Cook, he rejected the notion of functionalist structures being labelled 'heroic,' instead characterising them as 'villainous'. Fortunately, only two critics adopted such a superficial and prejudicial stance during the course of the project's development. While debating such matters can be intellectually stimulating, these discussions often reach an impasse, yielding limited theoretical advancement. This thesis demands an open and analytical approach, one that can peel away universal layers to uncover specific details, and look beyond visual representation to grasp the underlying substance.

The greatest frustration arises when ideas are dismissed without reasoned counterarguments. Statements such as 'a mega-structure is irrational' or 'a mega-structure is a villainous endeavour', hold no value unless accompanied by a rational critique. To label something irrational without justification is indicative of a prejudicial viewpoint.

This research has been an intellectually stimulating and insightful journey, deepening the exploration of the relationship between universality and specificity, as well as the interplay between substance and manifestation. Throughout the process, the study has demonstrated effective strategies for constructing arguments and challenging prejudicial perspectives, fostering a more critical and reflective approach to architectural discourse. The findings hold lasting significance, offering valuable contributions to both theoretical and practical applications. Beyond its immediate scope, the thesis serves as a foundation for future inquiries, enabling continued engagement with evolving ideas, methodologies, and interpretations that will shape architectural and urban discourse in meaningful and progressive ways.

Bibliography

Adams, P., 1994. Principles of Nutrient Management in Hydroponic Culture. *Acta Horticulturae,* Volume 361, pp. 193-203.

Adams, P. & Ho, L. C., 1989. Nutrient Solutions for Hydroponics. *Journal of Horticultural Science,* 64(3), pp. 213-222.

Alloway, B. J., 1995. *Heavy Metals in Soils.* 2 ed. London: Blackie Academic & Professional.

Bachelard, G., 1964. *The Poetics of Space.* Boston: Beacon Press.

Bachelard, G., 1971. *The Poetics of Reverie.* Boston: Beacon Press.

Balmond, C., 2003. *Informal.* Munich: Prestel Verlag.

Basalla, G., 1988. *The Evolution of Technology.* Cambridge: Cambridge University Press.

Benemann, J. R., 1997. CO_2 mitigation with microalgae systems. *Energy Conversion and Management,* 38(S1), pp. 475-479.

Bertolini, L. & Spit, T., 1998. *Cities on Rails.* London: E & FN Spon, an imprint on Routledge.

Betsky, A., 2003. *Considering Rem Koolhaas and the Office for Metropolitan Architecture: What is OMA?.* Rotterdam: NAi Publishers.

Bristol City Council, 2002. *The Redcliffe Futures Masterplan,* Bristol: Bristol City Council.

Bristol City Council, 2005. *Tall Buildings Supplementary Planning Document (SPD 1).* Bristol: Bristol City Council.

Bristol City Council, 2006. *Future of Redcliffe: Supplementary Planning Document (SPD 03).* Bristol: Bristol City Council.

Britton, J., 1813. *An Historical and Architectural Essay Relating to Redcliffe Church, Bristol.* London: Longman, Hurst, Rees, Orme, and Brown.

Building Research Establishment, 2002. *Recovering and Reusing Timber - A Guide for Clients and Contractors,* Watford: BRE.

Carbon Trust, 2008. *Algae Biofuels Challenge: Advancing Sustainable Energy Solutions.* [Online] Available at: www.carbontrust.com

Carruthers, S. P. & Jones, M. R., 1983. *Biofuel production strategies for UK agriculture.* Reading: Centre for Agricultural Strategies.

Chisti, Y., 2007. Biodiesel from microalgae. *Biotechnology Advances,* 25(3), pp. 294-306.

Clegg, P., 2008. Review of the University of Bath's End of Year Show 2008. *The Architects Journal,* 17 June.227(23).

Cole, R. J. & Kernan, P. C., 1996. Life-cycle energy use in office buildings. *Building and Environment,* 31(4), pp. 307-317.

Cook, P., 1991. *Archigram.* Basel: Birkhauser.

Cooper, A., 1979. *The ABC of NFT: Nutrient Film Technique.* London: Grower Books.

Crompton, D., 2001. *Archigram.* New York: Princeton Architectural Press.

DCLG, 2007. *Approved Document B: Vol 2, Buildings other than dwelling houses,* London: TSO.

Dickerman, J., 1975. *Discovering Hydroponic Gardening.* California: Woodbridge Press Publishing Company.

Dovey, K., 1998. Multiplicities and complicities: signifying the future at Euralille. *Urban Design International,* 3(3), pp. 89-9.

Egan, J., 1998. *Rethinking Construction: The Report of the Construction Task Force.* London: Department of the Environment, Transport and the Regions.

Environment Agency, 2007. *Remediation of Contaminated Land: A Guide for Developers,* Bristol: Environment Agency.

Forestry Commission, 2006. *UK Forestry Standard: The Government's Approach to Sustainable Forestry,* Edinburgh: Forestry Commission.

Foucault, M., 1989. *Archaeology of knowledge.* Oxford: Routledge.

Foucault, M., 2002. *The Order of Things: an Archaeology of the Human Sciences.* Oxford: Routledge.

Gunawardena, K., 2008. *Garden Inn in the sky.* Bath: University of Bath.

Gunawardena, K. R., 2004. *A short essay on Deconstructivist Architecture,* Bristol: University of the West of England.

Gunawardena, K. R., 2005. *The Pithay of Bristol: memories of war and post-war reconstruction.* Bristol: University of the West of England.

Gunawardena, K. R., 2006. *A Theorist and his Practice: a critique of the architect-theorist, Rem Koolhaas.* Bristol: University of the West of England.

Gunawardena, K. R., 2008. *Mythological symbols as ornament in the works of Geoffrey Bawa.* Bath: University of Bath.

Gunawardena, K. R., 2009a. *The Berkeley Prize Essay: Instances of the liminal,* Berkeley, California: University of California, Berkeley.

Gunawardena, K. R., 2009. *Lunuganga, the instance of a dwelling: an analysis considering Heidegger and Jung.* Bath: University of Bath.

Gustavsson, L., Joelsson, A. & Sathre, R., 2006. Life cycle primary energy analysis of wood substitution in construction. *International Journal of Life Cycle Assessment,* 11(4), pp. 240-246.

Hammond, G. & Jones, C., 2008. *Inventory of Carbon & Energy (ICE) Version 1.6a,* Bath: University of Bath, Sustainable Energy Research Team.

Hammond, G. P. & Jones, C. I., 2006. Embodied energy and carbon in construction materials.. *Proceedings of the Institution of Civil Engineers – Energy,* 161(2), pp. 87-98.

Harrison, R., 2004. *Steel Construction: Design and Practice.* 2 ed. London: Spon Press.

Harris, R., 1993. *Discovering Timber-Framed Buildings.* Princes Risborough: Shire Publications.

Hauser, S., 2007. *Peter Zumthor: Therme Vals.* Zurich: Scheidegger & Spiess.

Health and Safety Executive (HSE), 2007. *Construction Site Welfare Facilities: Legal Requirements and Best Practices.* [Online] Available at: www.hse.gov.uk

Heidegger, M., 1975. *Poetry, Language, Thought.* New York: Harper & Row Publishers.

Henley, P., 2008. *In Bloom: Growing Algae for Biofuel, BBC News.* [Online]
[Accessed 2009].

Holl, S., Pallasmaa, J. & Perez-Gomez, A., 2007. *Questions of Perception: Phenomenology of Architecture.* Tokyo: Architecture and Urbanism Publishing Co. Ltd.

Ison, W., 1952. *Bristol: An Architectural History.* London: Faber & Faber.

Jensen, M. H., 1997. Hydroponic Cucumber Production. *HortScience,* 32(4), pp. 482-485.

Jensen, M. H., 1997. Hydroponic Pepper Production. *HortScience,* 32(4), pp. 482-485.

Jensen, M. H., 1997. Hydroponics worldwide: A technical overview. In: International Symposium on Growing Media and Hydroponics. *Acta Horticulturae,* Volume 481, p. 719–730.

Jensen, M. H., 1999. Hydroponics Worldwide: State of the Art in Soilless Crop Production. *Acta Horticulturae,* Volume 481, pp. 719-729.

Jensen, M. H. & Collins, W. L., 1985. Hydroponic Vegetable Production. *Horticultural Reviews,* Volume 7, pp. 483-558.

Jung, C. G., 1975. *The Collected Works of C. G. Jung.* London: Routledge & Keagan Paul Ltd.

Koolhaas, R. & Mau, B., 1995. *S, M, L, XL.* New York: Monacelli Press inc.

Lambers, H., Chapin III, F. S. & Pons, T. L., 1998. *Plant Physiological Ecology.* New York: Springer.

Lang, P. & Menking, W., 2003. *Superstudio: Life Without Objects.* Milan: Skira editore.

Levene, R. C. ed., 1998. 1987-1998 OMA / Rem Koolhaas. *El Croquis,* Revised omnibus volume(53+79).

Mathews, S., 2005. *The Fun Palace: Cedric Price's Experiment in Architecture and Technology, Technoetic Arts, Intellect Ltd, Bristol, UK.* Bristol: Intellect Ltd.

McGourty, C., 2009. Global crisis 'to strike by 2030'. *BBC News* , 19 March .

Meade, M. K., 1994. Euralille: the instant city. *Architectural Review,* December , Issue 1174, pp. 83-6.

Menu, I., ed., 1996. *Euralille: The Making of a New City Centre - Koolhaas, Nouvel, Portzamparc, Vasconi – Architects.* Basel: Birkhauser Verlag AG.

Mical, T., ed., 2004. *Surrealism and Architecture.* Oxford: Routledge.

Millerd, J., 1673. *Millerd's Bristol Map, 1673: An Exact Delineation of the Famous Citty.* Bristol: Bristol Museums.

Molan, C., 2001. *The Impregnable City: A History of Bristol Castle.* London: Historical Press.

Morgan, L., 2005. *Hydroponic Tomatoes for the Home Gardener.* New Zealand: New Zealand Hydroponic Supplies.

Nelkin, D. & Pollack, M., 1977. The politics of participation and the politics of science. *Social Studies of Science,* 7(2), p. 137–154.

Norberg-Schulz, C., 1980. *Genius Loci: Towards a Phenomenology of Architecture.* London: Academy Editions.

Pallasmaa, J., 2005. *The Eyes of the Skin: Architecture and the Senses.* 2nd ed. Chichester: Wiley Academy Press.

Patil, V., Tran, K. Q. & Giselrød, H. R., 2008. Towards sustainable production of biofuels from microalgae. *International Journal of Molecular Sciences,* 9(7), pp. 1188-1195.

Premuzic, Z., Garate, A., Bonilla, I. & Carpena, R. O., 1998. alcium, Iron, Potassium, Phosphorus, and Vitamin C Content of Organic and Hydroponic Tomatoes. *Journal of Plant Nutrition,* 21(10), p. 2141–2153.

Price, C., 1984. *Cedric Price.* London: Architectural Association.

Purdy, J., 2003. *Sustainable Timber Use in Construction,* London: Building Research Establishment.

Resh, H. M., 1981. *Hydroponic Food Production.* California: Woodbridge Press Publishing Company.

Resh, H. M., 2001. *Hydroponic Food Production: A Definitive Guidebook for the Advanced Home Gardener and the Commercial Hydroponic Grower.* 6 ed. Boca Raton: CRC Press.

Sadler, S., 1998. *The Situationist City.* Cambridge, Mass.: MIT Press.

Sadler, S., 2005. *Archigram: architecture without architecture.* London: MIT Press.

Schenk, P. M. et al., 2008. Schenk, P.M., Thomas-Hall, S.R., Stephens, E., Marx, U.C., Mussgnug, J.H., Posten, C., Kruse, O. and Hankamer, B., 2008. Second generation biofuels: high-efficiency microalgae for biodiesel production. *BioEnergy Research,* 1(1), pp. 20-43.

Sheldrake, R., 1988. Hydroponic Herb Production. *HortTechnology,* 3(4), pp. 422-427.

Spiller, N., 2006. *Visionary Architecture: Blueprints of the Modern Imagination.* London: Thames & Hudson.

Steel Construction Institute, 2006. *Sustainable steel construction: the facts,* Ascot: Steel Construction Institute.

Steiner, A. A., 1984. Soilless Culture in Horticulture. *Horticultural Reviews,* Volume 6, pp. 177-228.

Stoughton, R., 1969. *Hydroponics: Principles and Practice.* London: Butterworths.

Theophrastus, 1992. *On the Causes of Plants.* Cambridge, MA: Harvard University Press.

Tracey, D., 2007. *Guerilla Gardening: A Manualfesto.* British Columbia: New Society Publishers.

TRADA, 2005. *External Timber Cladding: Design, Installation and Performance,* High Wycombe: Timber Research and Development Association.

Tschumi, B., 1997. *Architecture and Disjunction.* 3rd ed. Cambridge: MIT Press.

UK Government, 2007. *The Construction (Design and Management) Regulations,* London: The Stationery Office.

Vidler, A., 1992. *The Architectural Uncanny: Essays in the Modern Unhomely.* London: MIT Press.

Viljoen, A., 2005. *Continuous Productive Urban Landscapes: Designing Urban Agriculture for Sustainable Cities.* Oxford: Architectural Press.

Wheeler, R. et al., 1996. A review of controlled environment agriculture and its applications to human life support systems. *Advances in Space Research,* 18(4-5), p. 271–283.

Wigley, M. & Nieuwenhuys, C., 1998. *Constant's New Babylon: The Hyper-architecture of Desire.* Rotterdam: 010 Publishers.

Woods, L., 1992. *Anarchitecture: architecture is a political act.* London: Academy Editions / St. Martin's Press.

World Steel Association, 2008. *World Steel in Figures,* Brussels: World Steel Association.

WRAP, 2007. *Reclaimed Building Materials Guide,* Banbury: Waste & Resources Action Programme.

Zumthor, P., 2006. *Atmospheres: Architectural Environments - Surrounding Objects.* 1st ed. Basel: Birkhäuser.

Zumthor, P., 2006. *Thinking Architecture.* 2nd Expanded ed. Basel: Birkhäuser.