Reviewing Green Roof Design Approaches: Case Study of Residential Buildings

Bertug Ozarisoy

Submitted to the
Institute of Graduate Studies and Research
in partial fulfillment of the requirements for the Degree of

Master of Science
in
Architecture

Eastern Mediterranean University
December 2013
Gazimağusa, North Cyprus

Approval of the Institute of Graduate Studies and Research

Prof. Dr. Elvan Yılmaz
Director

I certify that this thesis satisfies the requirements as a thesis for the degree of Master of Science in Architecture.

Assoc. Prof. Dr. Özgür Dinçyürek
Chair, Department of Architecture

We certify that we have read this thesis and that in our opinion it is fully adequate in scope and quality as a thesis for the degree of Master of Science in Architecture.

Assoc. Prof. Dr. Mukaddes Fasli
Supervisor

Examining Committee

1. Assoc. Prof. Dr. Beser Oktay Vehbi
2. Assoc. Prof. Dr. Mukaddes Faslı
3. Asst. Prof. Dr. Nil Pasaoglulari Sahin

ABSTRACT

High density of the residential areas and steep land value in the cities have driven people to maximize liveable and productive spaces in urban settings. This includes the reinvention of roof functions extending merely as a protection from the elements to a platform of housing green building technologies such as green roofs. Increased interest in green roofs have led to advances in technology. An entire industry has sprung up which specializes in lightweight growing materials, roofing membranes, plant containers and plant stock. Many research have focused on developing lighter, thinner green roof systems at a reduced cost that have a minimal impact on the building structure or addressing concerns about leakage and resultant liability. Green roof generally requires thick growing media and a more integrated approach. They are often categorized by their system type; extensive, simple-intensive, intensive, container or greenhouse, which is why this research focuses on mainly extensive and intensive green roofs.

As land becomes scarce and development is inevitable in meeting growing needs of the current population, green spaces have paved the solution in enhancing the value of a development in any notion. One promising option is the greening of buildings by implementing green roofs. This will increase the percentage of greenery in urban built-up areas and bring back the vanishing urban green space.

Green roofs can bring a patch of country back into even the most over developed urban space. Such a reminder of our place within nature is vital to our sense of well-being.

The green roof is not the only solution for improving the quality of the existing environment but it is suggested as a lucrative and feasible solution for implementing within its design elements and construction systems. The construction phases and selection of appropriate green roof design materials play a crucial role to enhance the quality of space. This research seeks to understand green roof design implementations on selected residential buildings. The design of green roofs in residential buildings are examined on how architects apply green roof design elements on these particular projects and how these green systems alleviate spatial organization of buildings and its surrounding environment.

This research is aimed to review green roof design approaches in the case studies of residential buildings. Initially, fifty buildings were reviewed. The five case studies were selected because of their unique building typology, green roof concepts and design elements. The research has been organized into four chapters. The first chapter, introduces the research. Then the second chapter discusses the theory supported by building typology and its design elements in detail. The third chapter, evaluates five case studies in residential category within their typology and design elements. Finally the fourth chapter provides conclusions.

The results obtained through the theoretical research, literature review and analysis, shows that green roofs designs are given more importance on residential buildings. Results from this research indicate that the vegetated space usage in high density housing projects will eventually provide a theoretical framework that can be oriented in the decision-making process for green roofs. The methodology, findings and results emphasize the potential for improving the green roof design implementations and durability of residential building functions by understanding the design

environment and the interactions between the surrounding environment and green roof design. These collective requirements have created challenges to develop exciting and innovative green cities offering future studies for green roof design.

Key Words: Collective Living, Ecology, Green Design, Green Roof, Green Roof Approach

ÖZ

Yüksek yoğunluk ve arazi değerlerinin artması, insanları yaşanılabilir ve kendi ürününü üretebilen kentsel yaşam alanlarına yönelmesini sağlamaktadır. Yaşanılan bu yenilik, çatıların fonksiyonunu büyük bir etkide genişleterek, koruyucu bir eleman olarak yüksek yoğunluklu konutların sürdürülebilirliğinde kullanımlarını arttırmaktadır. Yeşil çatıların kullanılmasındaki artış, teknolojinin gelişmesi sonucu ortaya çıkmıştır. Günümüz endüstrisi, büyük bir ölçüde gelişerek, hafif çatılarda uygulanabilir bitki, çatı izolasyonları, bitkilerin yetişebileceği modüler alanlar ve bitki stoklanmasına olanak sağlamaktadır. Araştırmaların büyük bir bölümü hafif uygulanabilir çatı sistemleri üzerine olmakla birlikte bu araştırmalar çatıların sürekliliği ve uygulanabilirliği üzerine olan etkilerini göstermektedir. Yeşil çatılar genellikle hafif çatı uygulamalarını gerektirmektedir. Bu çatılar, genellikle çeşitli kategori altında değerlendirilmektedir; yüksek yoğunluklu, basit-hafif yoğunluklu, hafif yoğunluklu, modüler alanlar veya yeşil evler. Yapılan bu araştırmalar, daha çok yüksek yoğunluklu çatılar ve hafif yoğunluklu çatıları incelemektedir.

Yaşanılan arazi sıkıntısı ve gelişmeler artmakta olan nüfusun kaçınılmaz bir sonucu olarak ortaya çıkmaktadır. Yeşil çatıların kullanımı ortaya çıkan bu soruna bir çözüm alternatifi oluşturmaktadır. Yeşil çatıların uygulanması ayrıca yeşil binaların değerini de arttırmaktadır. Ortaya konulan bu çözüm yüksek yoğunluklu alanlarda yeşil alan yüzdeliğni arttıracak ve kullanılmayan yeşil kentsel bölgelerin tekrardan kazanımını sağlayacaktır. Yeşil çatının tanımı olarak, önceden var olan binanın üzerine hafif modüler sistemler kullanılarak inşa edilen ve doğrudan doğal toprak ile temas etmeyen insan yapıları olarak bahsi geçmektedir. Tanımlanabilen iki tip yeşil çatı

bulunmaktadır; yüksek yoğunluklu ve hafif yoğunluklu çatılar. Hafif yoğunluklu çatılar, izolasyon kullanılarak en çok 150mm derinliğe kadar inşa edilebilir ve genellikle çok fazla büyümeyen bir bitkilendirmeye olanak vermektedirler. Yüksek yoğunluklu çatılarda izolasyon kullanılarak 150mm den daha fazla derinliğe sahip çatıların inşa edilmesine olanak veren ve ayrıca daha hızlı büyüyebilen bitkilerin kullanımına olanak vermektedir. Yeşil çatılar üzerine yapılan araştırmalar birçok pozitif çevresel etkilerin olduğnu göstermektedir; sel tehlikesini aza indirgediği, yağmur sularının toplanmasındaki kaliteyi arttırdığı, kentlerin ısınmasını önlediği, binaların enerji verimliliğni arttırdığı ve kentsel doğal yaşam alanları sağladığı görülmektedir.

Bu araştırma, hedef olarak yeşil çatı uygulamalarının yüksek yoğunluklu konutlarda olan tasarım yapılarını gözden geçirmektedir. Bu araştırma üç kısımdan oluşmaktadır. Öncelikle ilk kısımda probem saptanmakta ve tanımlanmaktadır ve daha yeşil çatıların kullanım alanları ve tasarım elemanları üzerine üzerine teorik bir çalışma yapılmaktadır. Yapılan bu araştırmanın en son kısmında önceden saptanan konut kategorisindeki beş örnek analiz edilerek, bu yüksek yoğunluklu konutlardaki yeşil çatı uygulamalarının yoğun konut tasarımlarındaki yaklaşımı incelenmektedir.

Yeşil çatıların estetik etkisi, mekana kendine özgü bir karakter yaratmakta olup doğaya ve zamana karşı pozitif bir katkı sağlamaktadır. Yüksek yoğunluklu konutlara uygulanan yeşil çatı tasarımları mekan kalitesini arttırmaktadır. Yeşil çatı ve ekolojik çevre ilişkisi arasındaki bağ yadsınmamaktadır. Ortaya çıkan bu etki sonucu tasarım kriteri olarak uygulanabilecek yeşil alan miktarı büyük bir öneme sahiptir. Ekolojinin insan yaratıcılığna olan etkisi, değişken, çok kökenli ve de

artistik bir amaç duymaktadır. Bu gelişmeler sonucu, artan bilimsel ekolojiye karşı durabilecek soyut bir çevresel kavram bulunmamaktadır.

Araştırma sonuçları, teoriyi ana hedef alan bir çalışma, daha önceden bu araştırma ile ilgili yapılan çalışmaların taraması ve de analizlerden oluşmaktadır. Bu araştırma sonuçları yeşil alanların uygulanabilirliği konusunda yaptırımlarda bulunmakla birlikte yüksek yoğunluklu konutlara teorik bir yaklaşımda bulunup daha sonradan karar-yapım aşamasında oluşacak olan yeşil çatı uygulamalarına katkı sağlamaktadır. Araştırmanın yapıldığı yöntem, bulgular ve sonuçlar sürdürülebilirliği ve kullanım süresini arttırmaktaki çevresel etkilerini hedef almaktadır. Yapılan bu araştırmalar yenilikçi yeşil şehirlerin tasarlanmasında ışık tutacak önemli bir kaynak oluşturmaktadır.

Anahtar Kelimeler: Yeşil Çatı, Yeşil Tasarım, Yeşil Çatı Uygulamları, Yüksek Yoğunluklu Konutlar

This thesis dedicated to my Family

ACKNOWLEDGEMENTS

I would like to thank Associate Professor Dr. Mukaddes Faslı for her continuous support and guidance in the preparation of this study. Without her invaluable supervision I could not have achieved this research.

My gratitude is also conveyed to Assistant Professor Dr. Nil Pasaoglulari Sahin and Associate Professor Dr. Beser Oktay Vehbi, lecturers of the Faculty of Architecture, whose support I will always be grateful for.

I am indepted to my family and close friends who have encouraged and supported me throughout my studies.

I am dedicating this study to them as a reflection of their importance in my life.

TABLE OF CONTENTS

LIST OF FIGURES

Chapter 1

INTRODUCTION

1.1. Problem Statement

Since the beginning of the twenty-first century and its highly intensified globalization, the green roof design has emerged as a compelling impetus for architecture in order to mediate contradiction between the drive for aesthetical, environmental and social maximization and the fragility of the natural environment. Cities and metropolitan regions are the newest and perhaps the most important venues in tackling the requirements of green roof designs and advancing a technology within the implementations of its design elements. Today, world inhabitants are aware of the so-called greenhouse effect resulting from the excessive emission of carbon dioxide and other heat tramping gases into the atmosphere, largely caused by our profligate dependency on massive building construction. The concomitant phenomenon of global warming has surely become one of the most traumatic transformations in the otherwise seemingly progressive trajectory of the cities.

One phenomenon of today’s dramatic changes on the environment is the designing of buildings which are ecologically friendly or designing green roofs for increasing the area of green spaces. Fieldson (2004) mentions that these conceptions can indeed slow down the catastrophic change of our environment due to designing alternative green spaces on the roof tops of any existing building.

It is certainly correct that green roof designs are quantifiable and that therefore the success of different architectural strategies is to some degree of the measurement of their quality. This applies to systems in a variety of spaces when designing indoor or outdoor spaces for users. This leads to create a sense of space within the different design requirements of green roofs.

Bruntland (1987) mentions, in recent years, green roof design has become synonymous to meet the needs of the present without compromising the ability of future generations to meet their own needs. Drawing on this ideology Andrews (1997) claimed that in seeking to engage with green roof design, its elements, concepts and implementations can be interpreted across a spectrum of practice and is almost incomprehensible in its breadth to alleviate within the world inhabitants. For instance, Guy and Farmer (2001) stated that the green roof concept is a contestable concept. They observe a privileged, techno centric agenda in the way in which green roof design interpretation is described that offers green space for the sensibilities of space identity. They assert that the so called green roof trends is entirely a social phenomena of the popular design. This is true in terms of functional continuity between indoor and outdoor spaces, but also, more crucially, in terms of social and cultural urban form. Green roof design in this regard is tied to integrate the built form into its specific context of climate, topography and vegetation as well as its specific culture.

Developing the systems of green roof is necessary and probably the only path left in the future of architecture aside from the complete absence that can begin to address the impacts of providing green roof designs and its installations to the world's population. Designing a green roof is a unique opportunity because it does not indicate the end of architecture as an aesthetic system nor does it indicate an imposition on architecture's creative enterprise.

The green roof concept is an aesthetic project at its heart where an aesthetic system can be used to form a symbiotic relationship between the city and its surroundings. If designers understand green roofs as part of the topological space of landscape, they will also be able to understand the sense of place within the relational system between the natural and built environments. This new approach cultivates an understanding of landscape as a human interface with nature, presenting a means by which to design a green roof in a conceptual manner, along with a renewed context of responding to the natural environment. On a simplistic level, Limbert (1998) mentioned that the connectivity of the landscape with the built-up environment is a horizontal process. An obvious demonstration of horizontal connectivity is the provision of green roofs and links in local planning which are crucial in making urban pattern more biologically viable.

It is clear that the central problem at the beginning of the 21st century is the question of climate change and the foreseeable scarcity of resources. All other global problems are by and large connected to this core challenge. On a simplistic level, if architects can find ways to cope with the rising demand of an expanding global population, architets have a chance to preserve life. Western societies have been leading the way in the establishment of different approaches to green roof designs but they have also been taking into account the physical, social and economic aspects, which create the ecological damage to our planet. This new paradigm of green roof design, its elements and implementations, will require profound changes in the ways we conceptualize cities and metropolitan regions such as seeing them as complex systems of environmental integrity, as well as in the ways we plan and manage them.

This research includes a wide range of research material in order to enable the reader to understand the term of the ‘green roof’. The research will examine the issues of green roof top approaches in terms of their design elements and implementations. The methodology for understanding green roof design assessment and dimension of its design elements have been derived from questioning design elements of green roofs in five selected residential buildings to show similarity or differences in response to the basic requirements of green roof design.

After highlighting the importance of green roof design for high densely populated areas, the theoretical framework, design elements and selected residential buildings have been examined in terms of responding to the review of green roof design approaches. The interpretation of selected residential buildings and the theoretical framework of green roofs are evaluated at the end of the research.

1.2. Aim of the Thesis

Understanding the problems caused by the scarcity of land and the decrease in energy resources as a result of fast rise in population growth and urbanization, leads to making this research review of the green roof and its design elements as the essential components for reclaiming the nature and to alleviate the habitat loss. A Green roof strategy is not the only solution for improving the quality of the existing environment but is suggested as a lucrative and feasible solution for implementing it within most projects. People should have a much wider responsibility for the environment enveloping our architecture – the air, water, earth and climate – before designers even start consolidating green roof design approaches because it's the people of this planet who will need to implement this new way of living. In this research it is aimed to review green roof design approaches as a case study of residential buildings.

Accordingly, the main and sub-research questions which arise are:

The main question is: What are the main design approaches for the green roof design of the residential buildings?

The sub-questions are risen as such;

- What is the main term of a green roof?
    - How can a green roof be defined?
    - What are the role of green roofs?
    - What is the effect of the space strategy on green roofs?
    - How has the landscape character of green roof changed throughout the years?
    - What kind of spaces are used for green roof?
    - What are the design elements of green roof?

- How can green roof approaches contribute to the design of residential buildings?
    - How can the typology of residential units effect on green roof design?
    - What are the main green roof design elements of residential buildings?
    - What are the benefits of applying green roof design on residential buildings?

These questions would help to achieve the research objectives such as:

- To understand the construction of green roofs and its design elements
- To derive a methodology to examine the theoretical framework of the green roofs.
- To search for example of the residential buildings having a well-organized green roof design elements for densely populated cities.
- To provide case studies to understand the implementations of green roof design elements.

1.3. Limitation of the Thesis

Preliminary research reveals that a key goal of green roof design is to achieve a sense of modern urban living despite burgeoning urban populations. Gill (2007) mentioned that success will depend on even increasing sophistication of approaches to the design of green roof elements and the development of quantitative, measurable targets for such green roof conceptual schemes. Among these dimensions of green roof design approaches, this research is focusing on the theoretical framework of green roof design elements and its constructional systems, which are the main components of designing green roofs in selected buildings. The role and space strategy of green roofs have been associated with key principles of design elements in this research. There are many green roof examples, which have been evaluated through a selected of five different residential buildings for implementing green roofs and its requirements, which are similar in addressing these challenges and take advantage of the opportunities they present. Additionally, in addressing all the key principles of theoretical issues of our time, green roof design and our architectural presence, has a focal role to play in creating a green city model or garden city model to alleviate and respond to green roof design requirements.

In this research, green roof implementations have been evaluated through creating a green sensual experience between indoor and outdoor spaces. Residential buildings have been examined as they are classified according to their typology and elements, since space usages and design interpretations are related to include effective measures that will help to adapt to the already inevitable changes. An example of this is using a variety of approaches such as designing a greening community corridor or elevated green-street as a concept of green roof design which are composed of rivaling the quality of space which has been provided whilst also considering the possible future development of the context. For this research initially, 50 residential buildings were analysed for selection of the case studies. Then, five case studies are selected and then evaluated in detail in terms of their typology, green roof design elements and the main findings according to green roof concepts.

1.4. Methodology

This research consists of a case study, documentary research and analysis. The study begins with a theoretical view of green roofs, which is mainly include documentary research. All the information obtained and interpreted by design elements of green roofs, are used for deriving a methodology for understanding the green roofs and its implementations.

The research focuses on how greening roof top surfaces might affect the existing ground garden characteristics how within the parameters of acceptable landscape ideas and considerations. The existing green landscape elements or spaces can be integrated, such as linking with nature providing perceptional ideas and identifying new horizons for the green roof spaces.

Based on theoretical research, the green roof has been used in underground buildings within connected podiums, office buildings, hotel and residential buildings. This research focuses on residential buildings and its design elements. Five residential buildings have been chosen as case studies for this research. Furthermore, in order to examine five residential buildings, an inventory chart shows the green roof design principles of how they might change the character of the housing typology. Five green roof designs on residential buildings are selected according to their housing typology, green roof design elements and their green roof concepts. The literature review has been taken as a basis for a descriptive explanation of the green roofs. This research also follows up the theoretical framework of green roofs, the role of green roofs, space strategy for green roofs, landscape form, history of the landscape and green roof then following roof gardens for different building types and their design elements (see figure 1.1).

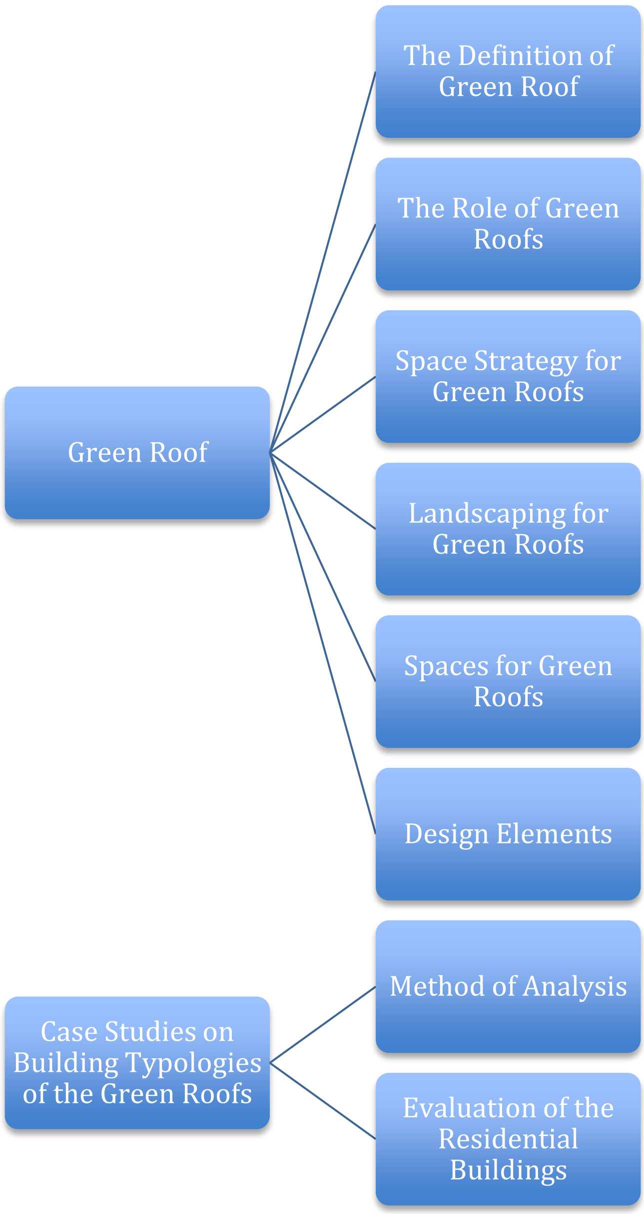


Figure 1.1: The methodology diagram of this dissertation.

Chapter 2

GREEN ROOF

In this chapter, theoretical information about green roof, the role of roof top gardens, space strategies for green roofs, landscaping for green roofs, history of the landscape and spaces for green roofs within the building types are presented.

2.1. The Definition of a Green Roof

The term 'green roof' is a vegetated space that is structurally integrated on the top of a man made structured roof, covering a definable area to use as a functional space. According to Capra (2003) the green roof offers a horizontal surface, providing opportunities of improving the existing environmental conditions in a broad term to identify the landscaping area, contributing to the overall systems of nature by understanding the interactions between its design elements, especially the relationship between the natural environment, and the interactions between social structure and the spatial functioning of the space. However a green roof strategy not only provides a heat island amelioration and thermal comfort for occupants, but also reduces energy consumption of buildings as well as adding aesthetic values to the environment (Cuito, 2000). Investigating the potential of green roofs, Southern Illinois University researchers categorized greening roofs into two groups - intensive roofs and extensive roofs. Extensive greening is thicker and heavier which can grow a wide variety of vegetations such as small trees, shrubs and bushes in a substrate depth more than 20 cm (see figure 2.1). Intensive greening is normally designed for the use of human entertainment which requires extra structural reinforcement (see figure 2.2). On the other hand, extensive roofs are suitable for lightweight buildings; the plants adopted are species of sedum, shrubs and bushes that need low maintenance and can be self-generative. Usually cost is lower than semi intensive or intensive green roofs (Hui, 2006). Dunnett and Kingsbury (2004) also mentioned that extensive green roofs have received the most research focus because they offer the most replicable design solutions and have more potential to be retrofitted on a large scale.

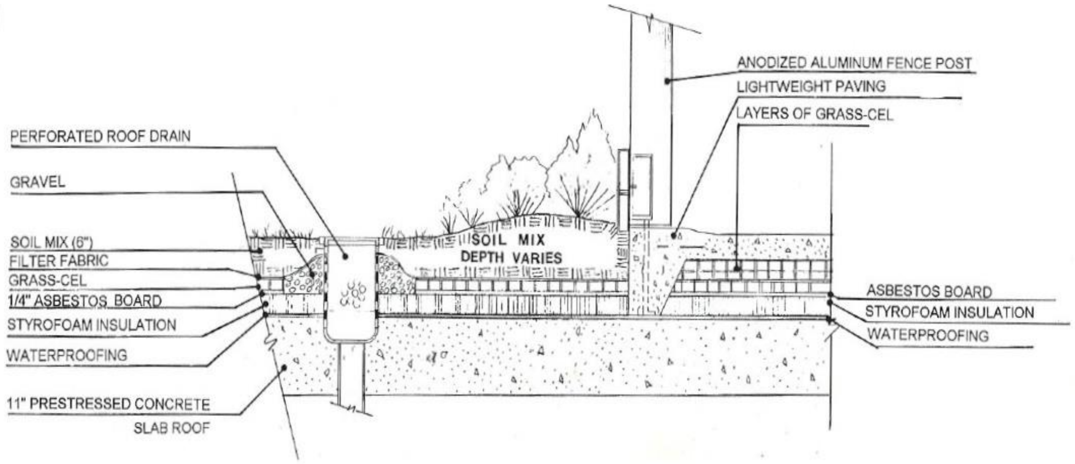


Figure 2.1: Section of extensive roof top garden. (Laterza, 1975, p.28)

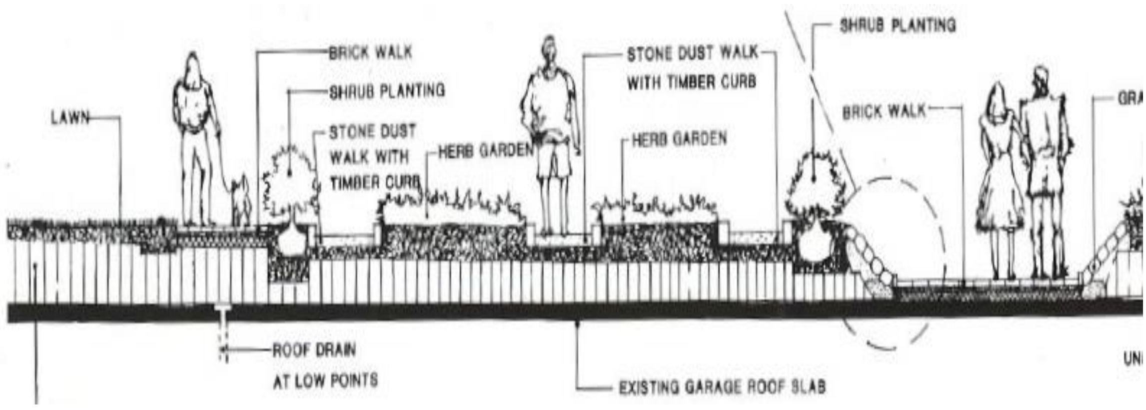


Figure 2.2: Section of intensive roof top garden. (Laterza, 1975, p.28)

Roof gardens can be delightful substitutes for natural landscaped areas at ground level with all of the amenities of gardens on the ground. Indeed, a roof garden can be virtually indistinguishable from a garden planted directly in the earth. Although, commonly envisioned as gardens in the sky, roofs of multistory buildings and roof gardens are often found at or just above grade on, at the top of roofs of underground structures. A roof garden is any planted open space, intended to provide human enjoyment or environmental enhancement that is separated from the earth by a building or other structure. It may be below ground level, or above the ground. While it may serve other functions as a means of circulation or access or a dining space, for example, a roof garden's primary purpose is to provide a place to enjoy.

The design of green roofs, it is clear that problems may stem from the fact that environmental destruction does not appear to be a matter that can be ameliorated or resolved through architectural aesthetics (see figure 2.3 and 2.4). In fact, addressing environmental destruction would curtail aesthetic possibilities. Although, public and research interest in green roofs has increased in recent years, most probably as a result of the variety of environmental advantages that are frequently attributed to them. These include: removal of air pollution, urban cooling (heat-island effects) and reduction of roof storm water runoff. However, it is becoming increasingly appreciated that the strength of these environmental benefits are dependent on the design of the green roof to be used (Bates, 2009) and that more research is needed before these potential advantages are fully understood and quantified (Oberndorfer, 2007).

The Architectural Institute of Japan (AIJ), (2005) defines a green roof top garden as one that is designed:

(i) to save energy and resources, recycle materials and minimize the emission of toxic substances throughout its life-cycle.

(ii) to harmonize with the local climate, traditions, culture and the surrounding environment.

(iii) to be able to sustain and improve the quality of human life while maintaining the capacity of the ecosystem at the local and global levels.

	
Figure 2.3: New Police Headquarters, Kowlon City. (Capra,2003,p.23)	Figure 2.4: New Electrical and Mechanical Services Department Headquarters,China. (Capra,2003,p.21)

The Purpose of Green Roof

A key component is the creation of appropriate green roof design. All disciplines involved in urban and architectural design need a deeper understanding and recognition of the functional performance and values of green roof design requirements and how to use them in practice. This helps to make green roof design the mainstream approach in urbanism. Siessor (1997) has also suggested that green buildings should be generically adaptable than utilitarian or encumbered with gratuitous formal gestures that soon become dated. Although a green roof design requires that the human environment be more than tolerable, it needs to be favourable, enabling people to thrive rather than merely exist, including the socially advantaged in society. These facts pose key challenges for greening roof top surfaces. Above all, they should be made of low-energy substances which are able to function in all systems weathers rather than high-energy synthetic substances which are often unable to withstand long term exposure to natural conditions without maintenance. A green roof design is impossible without a close integration with its environmental context. Therefore, a green roof approach has to alleviate such factors as microclimate, topography and vegetation, as well as the more familiar functional and formal concerns included in standard practice.

A key environmental benefit of installing green roofs is the creation of habitat for wildlife, which could potentially mitigate for habitat lost at ground level. However, research on this benefit remains in infancy, and the best way to design green roofs for habitat creation it is not yet clear. The Ecology of Urban Habitats research, (2012) conducted that desirable ecological characteristics of green roof habitats include:

(i) high species diversity

(ii) the provision of habitat for rare and endangered species

(iii) the provision of habitat for species with a high fidelity for the habitat lost at ground level.

Green roof design can significantly assist in reversing some of the bio diversity losses. Earlier treatises on green roof implementations research stated that rarities did not tend to occur in urban areas. The green roof design principles must address the regional climate conditions and the likelihood of new heat island effects arising from any new intensive concentration of built forms. This should be approached not on the basis of individual built forms, but at the level of the overall planning of an existent or new urban area. Whereas, for example, in existing cities, a reduction of heat island effects can be achieved by creating extensive roof top gardens. On green field sites, high and dense clusters of intensive buildings, should be avoided. This is important for several reasons. First, the increase in local temperature will affect the environment of the locality; second, by reducing the heat-island effect.

Established and emerging approaches to green roof design are primed to address these challenges and take advantage of the opportunities they present. Fundamental change in the organization and structure of our cities requires those in the allied design and planning disciplines to re-consider their approaches for designing and managing the landscape. Focusing on the potential that cities offer, landscape architects can envision, plan and design urban environments that are diverse and healthy for not only humans, but also for the myriad of other species that share these places.

Green roof installations facilitate and encourage more liveable and healthy lifestyles. Green areas have an important role in providing services such as sustainable potential for recreation, commuting routes in an attractive environment. In a green city, green areas are diverse and functional from an environmental perspective as well as experimental point of view. The green roof concept should be expanded in an urban setting to signify and include an array of recreational possibilities for its residents and potential to experience different landscapes. This requires vegetated surfaces be located in the right places according to local cultural and environmental values, sufficient in size, access and frequency. They also need to possess characteristics of a healthy atmosphere for inhabitants.

2.2. The Role of Green Roofs

In this section the role of green roofs is examined in terms of air quality, heat-island effect and storm runoff water management. This section contributes to create a theoretical background to understand green roofs impact on the environmental problems. This research aims to increase the quality of life while constructing the green roof of the man-made structure (see figure 2.5).

Figure 2.5: The diagram of the role of green roofs.

2.2.1. Air Quality

The role of vegetated roofs in preserving air quality is integral in core cities, such as metropolitan areas in the world, where air pollution is a major problem. Such strange anomalies occur in relation to the explosive growth of urbanized populations. Local authorities report an alarming prediction that by 2020 in China alone, some 300 million of the rural population will migrate to new or existing urban areas (see figure 2.6).

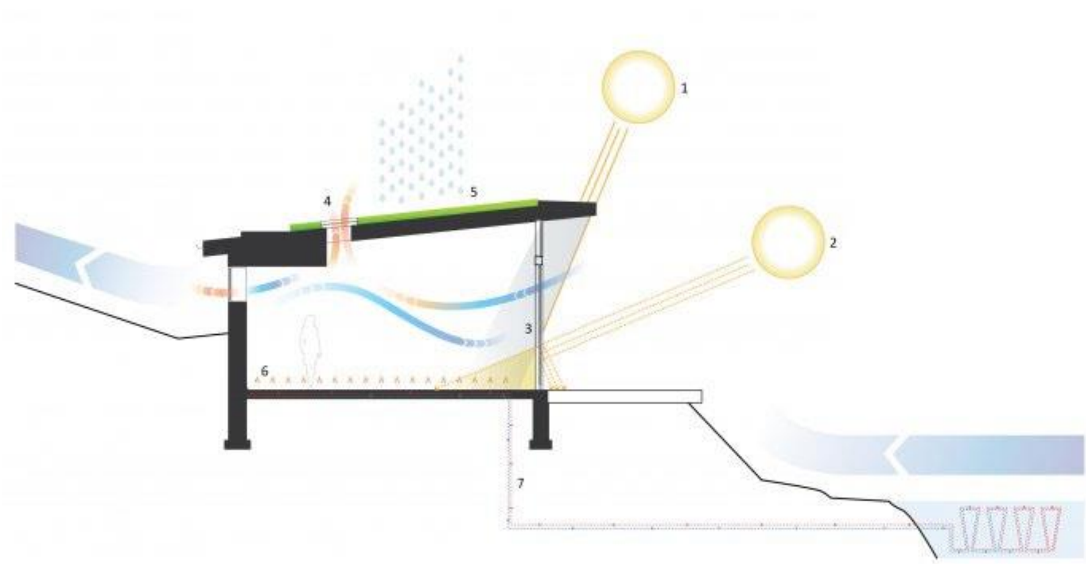


Figure 2.6: The green roof articulates fresh air through the interior spaces.

(Backman, 2007). A transfiguration on such a scale will only exacerbate the fact that many Third World cities are among the most polluted in the world. It is also significant that a heavy traffic industry and limited availability of land lead to limited vegetation. A recently published supplementary document is Mayor Johnson's Air Quality Strategy, URBED, (2012) which mentions that planning strategies and innovative measures play a crucial role to reduce emissions from road transport and in a radical step toward making the built environment more sustainable, there are new requirements to ensure that there are no negative impacts on air quality from future developments, requiring them to be air quality neutral or better. Meeting these requirements is likely to prove challenging but it is seen as important to realizing economic development. Creating planting space for vegetation on roof gardens, contributes to the air quality in urban areas (Hagan, 2005). Therefore, the improvement in air quality resulted from an investigation of a green roof theoretical framework based on the modification of the existing environment (Halliday, 2000).

Although it is recognized that green roof plants absorb carbon dioxide and produces oxygen, Mc Garvey (2004) concludes that the processing system for greening roof tops can not work efficiently because oxygen is generated by a sun lighten-driven system which is not a compound element of carbon-dioxide thus as a consequence; photosynthesis produces water instead of carbon-dioxide. Southern Illinois University research (2007) indicates that producing water via photosynthesis for greening roof tops is a short term solution because this system always preserves water during day light hours and as a result, it doesn't provide adequate water supply for plant sustainability.

European cities have experimented with new ways of taking into account these green roof systems in their decisions. The Vienna Environment report (2007) mentions that In Heidelberg, for instance, was one of the early pioneers in the development of the concept of eco-budgeting, helped elected officials understand and compensate for environmental damage. A number of Danish cities, including Copenhagen, have developed and are using some form of "green accounts" to track annual consumption of energy, greenhouse gas emissions. Many European cities have developed some form of environmental indicators, often through EU funding and support.

Another example of green roof planning is in Freiburg, Germany where a green design model creates air flows of clean air from the main forest region and facilitates or plan its green passage through the city to maximize the removal of air pollutants such as carbon dioxide emissions. Every master plan in Freiburg has incorporated this concept of clean air corridors which in turn affects such issues as the applications of green rooftops in order to support the flow of the air from the surrounded environment.

Southern Illinois University research, (2007) reported that air quality is problematic when constructing green roofs at lower temperatures in highly dense populated areas, due to smog and air quality. Although, Register, (2002) claims that warm air temperature in metropolitan areas constrains vertical circulation and collects nitrogen oxides from sunlight to produce smog. This situation brings advantages to green roofs for reducing the effect of high-concentrated air quality in urban areas.

2.2.2. Heat Island Effect

The roof top design must reduce the heat island effects as the consequence of inserting new structures or infrastructures into a locality, particularly in existing urban built environment and where the environment has existing concentrations of large quantities on small land footprints and areas having extensive uncovered roof surfaces.

The term 'heat island effect' is where the cities temperatures in their ambient environment is far greater than that of its surrounding non urban areas. Alternations in the land surface result in diverse micro-climates whose aggregate effect is reflected in the heat island (see figure 2.7). Globally, this is increasing, thus the following factors are regarded as the main causes of the heat-island phenomenon in cities:

(i) Changes in ground cover

- Presence of high density of buildings on ground at varying levels, sunlight is reflected off many surfaces. This means that buildings and ground surfaces absorb more solar radiation during the day, while the heat radiation towards the cold air temperature at night is distributed by the dense built environment.

- Except in spots with strong winds, decreased wind velocity is increased in densely built environments, compared with that in the sky above. Cities along the coast line provide a good example. In summer, although a cool sea breeze may blow high above the city during the day, the wind rapidly loses its velocity when it enters the built-up area and the potential for natural ventilation. As a result, enclosed spaces such as high rise buildings are often unable to diffuse heat and pollutants when they receive only weak gusts of wind. Hence these buildings are hot in summer and cold in winter.

- When there is a decrease in permeable ground surfaces such as earth and greenery, this results in an increasing amount of heat radiation from the ground, as the capacity to retain water is reduced and thus the cooling effect of evaporation is lost.

- Ground plane in cities is covered with materials of high thermal capacity such as asphalt, pavement and concrete; solar heat absorbed during the day is emitted at night, producing uncomfortably hot temperature rates even after dark.

(ii) High energy consumption

- In city centers for example, the heat generated by the consumption of energy by air conditioning equipment, lighting systems, automobiles and factories, is released into the atmosphere altering the natural temperature of the environment.

(iii) Air pollution

- Ambient pollution produces smog, which traps heat. This can raise temperatures by transforming an entire city into a glasshouse enclosed in a layer of polluted air.

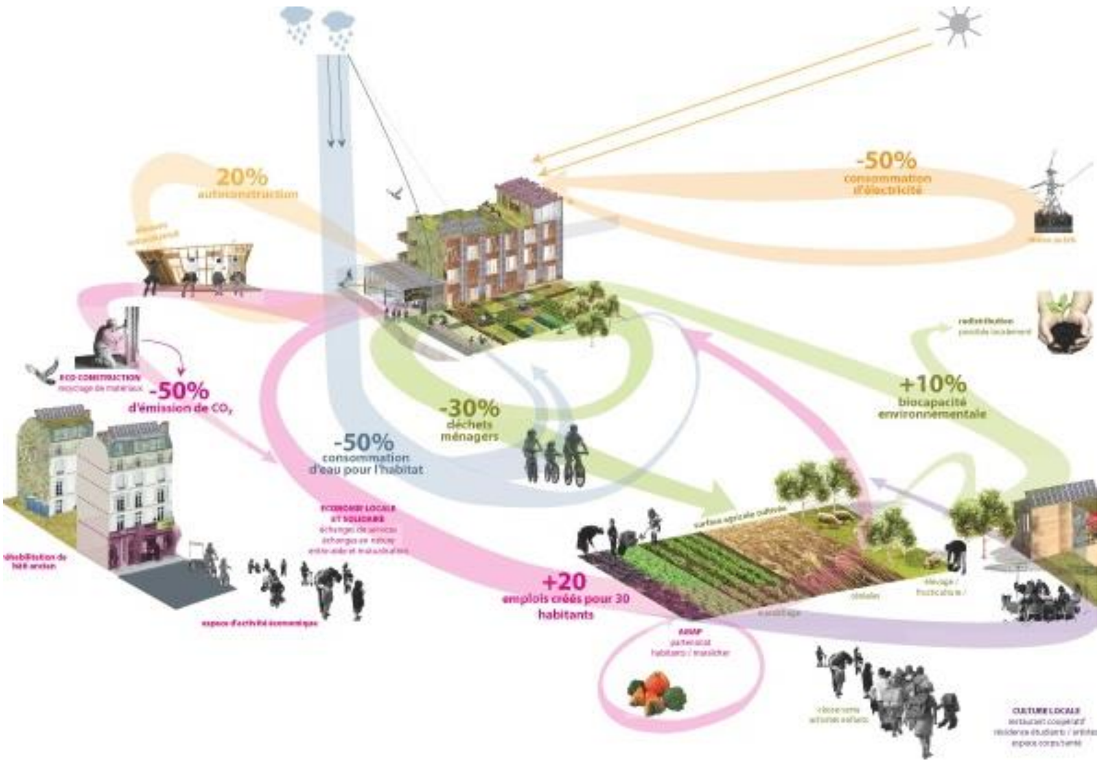


Figure 2.7: The green roof reduces heat island effect in the cities.

Research conducted at Southern Illinois University, (2007) has shown that plant life is important to help cool cities which have been destroyed and replaced with buildings and pavements, absorbing the sun's energy and holding the radiant heat. This situation is creating concentrations of heat which now surround densely populated areas, regulating the radiant heat in terms of sufficient cooling in the cities.

One of the most important points is that roof gardens can help to moderate climate in urban areas because high density areas are hotter than sub urban areas because most of the land area is covered by materials such as asphalt and concrete thus resulting in a heat-island effect. These hard-covered surfaces effectively increase the temperature of the environment. Consequently, man-made areas get hotter and still remain hotter than non-built up areas where vegetation reflects more sunlight. Initially, designing of roof gardens in the core cities contributed to decreasing the temperature by heat-retaining spaces with more reflective plant cover. This situation increases the evaporation of moisture, which controls cool air. Furthermore, Slobodkin (2003) suggests that urban areas become more comfortable within a temperature reduction, resulting in a significant reduction in terms of energy usage.

It is interesting to note that there are several technological advances providing opportunities to reduce the heat island affect which are absorbed by rooftops. It is a common and practical way for using highly reflective materials such as cool colour metal roofing, white membrane roofing and roofing tiles and shingles covered with ceramic chips reflecting the solar radiation instead of allowing energy to increase surface temperature of roofs. In addition, using reflective materials result in rooftops 15 to 40% cooler than rooftops covered with traditional roofing materials (Tuluca, 1997). Also researchers estimate that designing green roofs on 50 to 60% of the rooftops in densely populated cities could result in lower summertime temperatures (Retzlaff, 2007). These advantages lead to cooler cities during periods of increasing demand for electricity which helps to reduce carbon emissions thus creating an environmentally friendly environment (see figure 2.8).

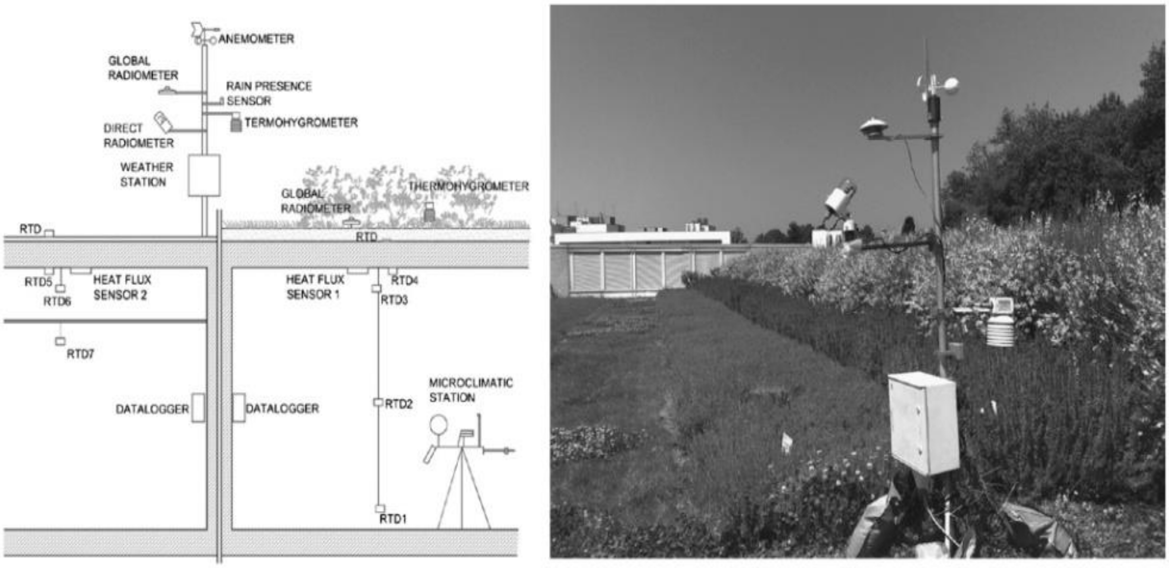


Figure 2.8: Monitoring apparatus of the green roof experimental site of the Regional Council of Marche (Italy). Positions of sensors (a) and picture of the green roof (b). **(**Retzlaff, 2007, p.57)

2.2.3. Storm Runoff Water

Rainwater harvesting or the collection and conservation of rainfall methods has been utilized for centuries to fulfill household and agriculture needs. The construction of water tanks in the courtyards of homes has solved the problem on how to haul water from a distant source. Rainwater harvest systems on domestic allotments, have the potential to be an important contributor to urban water self sufficiency by mitigating the ongoing water supply crises experienced by urban centers. The literature review has shown that many countries including Singapore, Denmark and Australia are now managing and legislating collection of rainwater from roof tops (Rygaard, 2011).

Storm water runoff from urban rooftops makes a significant contribution to urban water quality problems and nuisance flooding. Any technique that reduces the volume and rate of roof water runoff has the potential to contribute to improved storm water management. A living roof which is commonly referred to as green roof, vegetated roof, eco roof, roof garden or landscape over the structure provides an opportunity to mitigate storm water runoff at its source. Plants play a significant role in the functionality of a living roof for storm water management. Berghage (2005) mentions that depending on plant types, seasons and water availability, plants can contribute 20-48% total evapotranspiration via the process of transpiration, thus aiding storage recovery within the substrate.

In order to further explore green roof systems, another review of designing rooftops has focused on quantity and quality of runoff water. In older cities, heavy rain loads cause flooding. For instance, the New York sewer system for rainwater collection, does not stop sewage overflowing into the storm water tunnels which contributes to a change of direction of water flow to the nearby waterways. Consequently, when a heavy rainstorm hits New York, it sends raw, unprocessed sewage directly into the river. Green Roofs mitigate this problem by maintaining a water retention system. According to Register (2006) the rainwater emitted by the soil on a roof garden is as much as 15 to 20% thus regulating the collection of rainwater into a city's storm system. Additionally, Gedge (2005) explains that the designing of green roofs decreases the capacity of a city's storm-runoff system, reducing flooding and dramatically improving the quality of surrounding waterways.

The American Society of Landscape Architects research (2009) has shown that the main aim in collecting storm water from green roofs is to prevent the first flush of storm water going directly into the sewage facilities. Goode (2006) also suggests that greening roofs is an essential solution to retaining water on the rooftop where it can be evaporated back into the atmosphere. Research conducted at SouthernIllinois University (2007) also demonstrates that at least 4 inches of plant growth on rooftops is capable of collecting over 50% of annual rainfall. Another method of solving this problem, is the idea of plant growth formulations, using proper plant species and fertilizers for the plants, providing stabilization and minimizing the leaking of contaminants (Newton, 2007). According to Environmental Agency researchers (2009) they foresee the possibility of future green roofs being capable of segregating pollutants from the air and rainfall. However, the percentage of storm water retained by a green roof varies greatly from one geographic region to another due to rain frequency, intensity and duration as well as the type of green roof, plant selection and material (Newton 2007). Southern Illinois University research (2007) recorded that in the first 18 months of the experiment of storm water retention variations showed 39% for green roof blocks to 53% for plants built in place systems which contained plant growth when compared to runoff storm water on non planted rooftop surface (see figure 2.9).

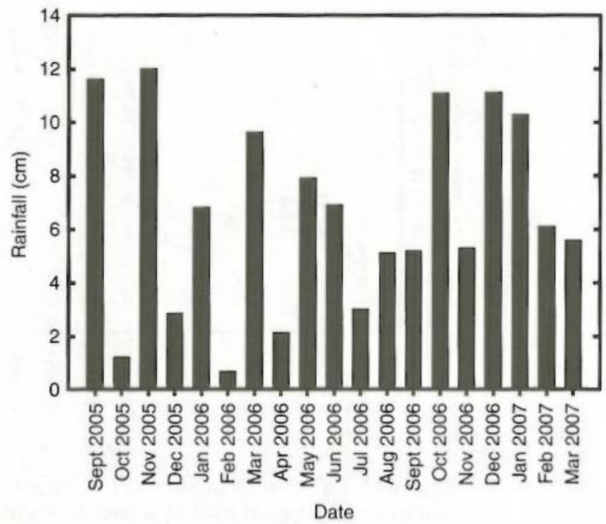


Figure 2.9: Total monthly rainfall collected in the green roof study at the Southern Illinois University Edwardsville Environmental Sciences field site for the study period of 9/05 to 4/07. (Southern Illinois University research, 2007, p.132)

From the storm water management perspective, green roofs can play an important role in modern urban drainage because of their ability to slow down and reduce runoff volume. Bengtsson (2005) mentions that high evapotranspiration from a green roof can reduce the annual runoff to less than half the precipitation. The temporal storage of water in the soil and vegetation reduces peak flow, which prolongs the time of concentration. A reduction in the peak flow of roof runoff implies that local urban flooding and combined sewers overflows can be considerably reduced.

Teemusk and Mander (2007) also mentions that the study of a green roof in Tartu, Estonia revealed that a light weight aggregates green roof has a considerable affect on the quality of run off water. Teemusk and Mander (2007) research concludes that during a 9-month monitoring period on two green roofs constructed within the Neuse river basin of North Carolina, identified that green roof functions was the best management practice for water retention and peak flow reduction. However, water quality data indicated that higher nutrient concentrations were present in the green runoff than those in the rainfall and control runoff respectively.

In the previous section environmental advantages of green roofs are discussed. The following section discusses space strategy for green roofs, landscaping for green roofs then follow up history of landscape and European green roof policies.

2.3. Space Strategy for Green Roofs

The literature reviews show that green roofs are established for a variety of reasons and with these come opportunities for their use. This research examine their contribution to the new design process :

(i) Greening roof top designs offer users a qualitative perception of the layers, which are comprised in building space. According to their design features, it can directly relate with environmental issues, which can transform and enrich cultural ideas of designing green roofs. It refers not only to the issue of environment and ecology but also to the mood of an entire nation, to its changing sense of identity and cultural belonging (Roger, 1997).

(ii) Greening rooftop designs are concerned with the visual expressions because they are built above the ground to catch vista points of context. These roof top spaces offer a congregation point for users where retrieval of memory, cultural enrichment of place, time and expectations, define design and character of the roof top garden. It is the visual sense of space and it’s established linkage between building and users. The landscape provides the most visible expressions and it measures the environmental atmosphere of rooftop.

(iii) Greening roof top designs are a contributed intervention of cultural habit, which may increase the cultural diversity that is contained in building occupation within its own aspects. It is socially informed to adapt its requirements to new lifestyles. Social aspects of greening rooftop show general movement toward awareness of building space as a landscape.

(iv) Green roof top designs are living vegetation installed on the roofs and could positively contribute to the mitigation of urban heat island and enhancement of building thermal and environmental performance.

These developments of enhancing the visual qualification reveals the importance of contextual characteristic and identifying realistic requirements for creating green roof spaces. Jullien (1995) mentioned that for designers to have a feeling for landscape, people have to lose their feeling of place. It is possible to broaden this sense of recovering landscape, invoking cultural and imaginative horizons, rather than limiting it to strictly environmental concerns which are a consistent base point of greening roof gardens assessments, reclaiming how one recognizes assessments through design, especially in reaction to the general state of environmental and cultural considerations that are characterized in time (see figure 2.10).

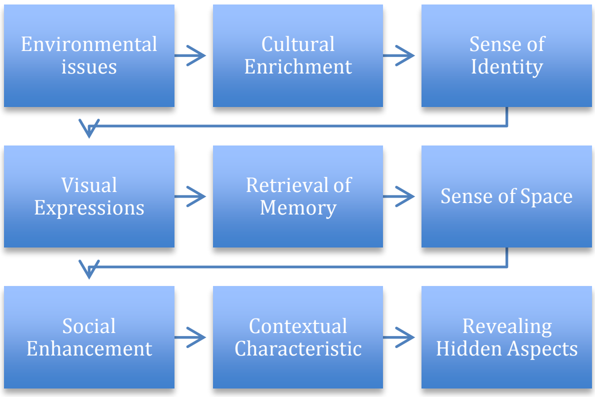


Figure 2.10: The table shows the space strategy of green roofs.

A green roof designs as a landscape, are not used as a decoration element at the stage of conceptualism. The notion of a landscape element defines which kind of purposes of this highly intuitive and experimental approach is consistent within greening roof top requirements. It is precisely this juxtaposition of preconceptions and the act of initial discovery that may generate a landscape visual and environmental process enhancing the interaction of users (Dines and Charles, 1997).

It is an essential point of the user that the awareness plays a vital role in the genesis of design, during the implementation of successive layers of usage, both visible and invisible. The landscape idea throughout much of this century has come mostly in the form of picturesque, rural scenery, whether for nostalgic, consumerist purposes or in the service of environmentalist agendas. (Beardsley,1998).

Designing such a green area has more opportunities than just increasing the aesthetic point of an area. When designed on a dignified scale, green roofs can play a crucial role in retaining a healthy eco-system, specifically in heavily built-up areas in highly dense urban population zones where air pollution needs to be addressed Frey (1999).

Additionally, it is now known that the use of that the greening roof tops concepts improve moderate hostile environmental conditions (Glass, 2001).

2.4. Landscaping for Green Roofs

The form of landscape design which, has been directly integrated within the usage of green roofs, creates some issues for the developing of the design strategies. Traditionally, landscape architecture is the art of incorporating functional and aesthetic concerns within the peculiarities of a particular location, inherently marking the character and specificity of the time and place (Hoyer, 1998). The quality of design is considered within the social patterns of context, accordingly, to examine social structures, aspects and expectations to improve spatial quality. It is also an opening for the spatial ideas, which attracts site usage.

The character of the landscape derives not only from consistent design criteria's but also, and perhaps in a larger measure, from a collective and organized approach to created aesthetic vocabularies within the context. Rather, it views the land and public space as an expression of ancient culture, or as a palimpsest that evidences all of the activities that contributed to the shaping of that particular landscape and no other (Marot, 1999).

Green roof design, engages multiple relationships defined by the nature and context. This is a rich and complex vision, aesthetic and ecological distribution, to enhance spatial quality. The definitive approach of landscape form was diccussed to understand its theoretical framework. The next section discusses the history of landscape, providing green roof examples. The following section evaluates today's green roofs within the world's high density city policies.

2.4.1. History of Landscape

This section is divided in five parts: firstly ancient roof gardens are given with an example of the hanging gardens of Babylon. Secondly, gardens of the Middle Ages and Renaissance is supported by Plazzo Piccolomini in Pienza, Italy, thirdly roof gardens from 1600 to 1875 with examples of sod roofs which is accepted as the roots of contemporary green roofs today then follow up roof gardens from the turn of the century until world war II and finally, pioneering green roofs in modern architecture (see figure 2.11).

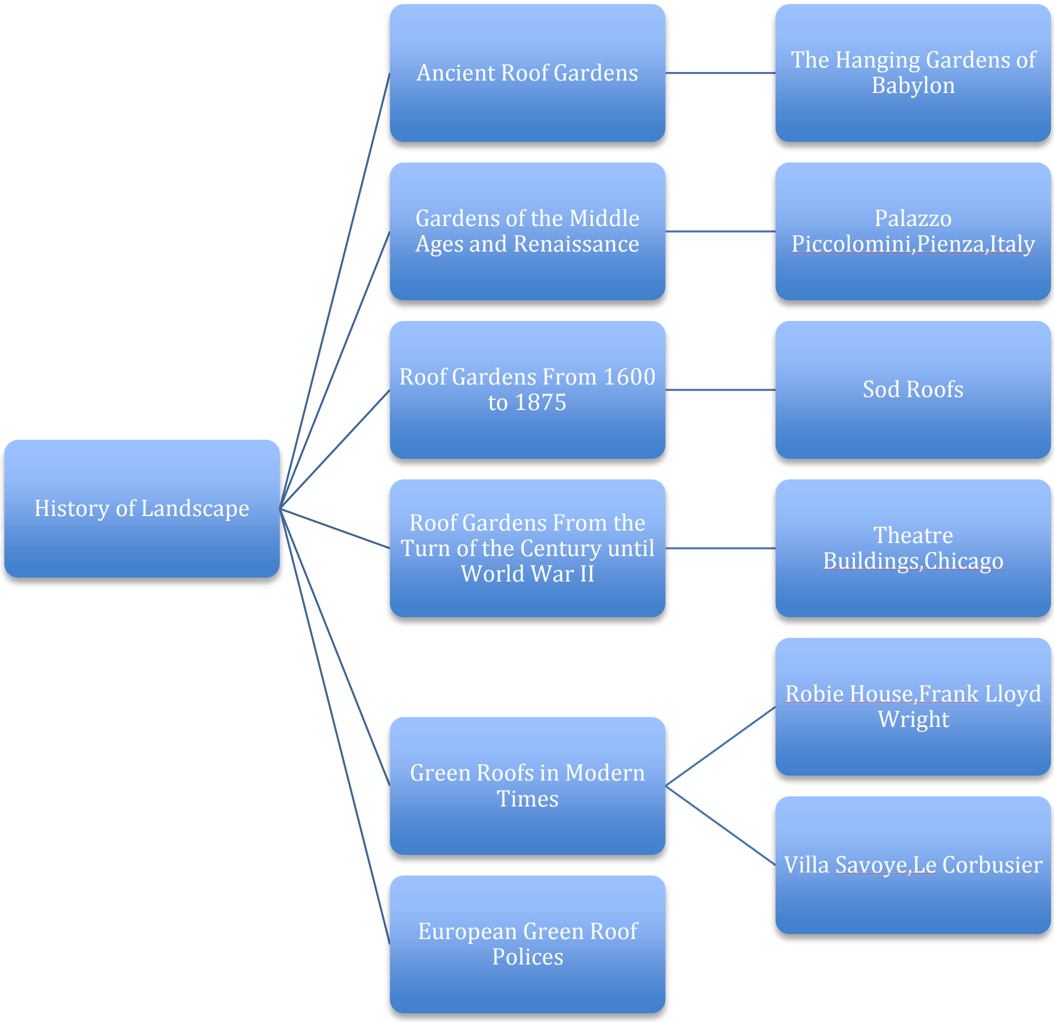


Figure 2.11: The chronology of understanding the history of landscape.

There is something fascinating about being up high, above people on the ground, looking farther and seeing more and feeling the different air of high places. To be in a garden on a roof is the ultimate experience of being up high, where one does not expect a garden to be. Even the people of ancient times knew this, and although many of the buildings that supported them have since disappeared, roof top gardens have existed since almost the beginning of recorded time. From the hanging gardens of Babylon to the roof gardens on top of multistory buildings today, the pleasure of being in a garden above the ground has been possible wherever the opportunity, skills and funds have permitted.

The history of living roofs, from eclectic roof gardens to bio diverse roofs based on construction rubble, is a fascinating journey through green roof top design. Control over substrate composition and isolation from polluted surfaces and ground water flows increase the chances of good natural/semi-natural habitat analogues being created on roofs, given time and practice (see figure 2.12 and 2.13).

Figure 2.12: The Moos Lake water filtration plant in Wollishofen, Zurich, Switzerland. These living roofs were created in 1914 by transfer of displaced meadow soils onto two hectares of concrete slab roofs. (Wells, 2010, p.73)

Figure 2.13: The roof habitats are an excellent analogue of the former ground level meadow habitats, so good in fact that as the original meadows of similar quality in the Canton. (Wells, 2010, p.73)

2.4.1.1. Ancient Roof Gardens

Because of the fleeting nature of ancient gardens, and especially roof gardens, little tangible evidence of their existence remains. They are, however, mentioned in classical literature to make assumptions of their existence a reasonable conclusion (Callender,1982).

The Hanging Gardens of Babylon

Probably the most famous roof gardens of all time, the fabled Hanging Gardens of Babylon were one of the Seven Wonders of the World (see figure 2.14 and 2.15). The gardens, probably constructed during the rebuilding of Babylon by Nebuchadrezzar II, were purportedly built by the king to console his wife, Amythis, who missed the greenery of her homeland, Media. No contemporary accounts of their construction or existence have been found (Osmundson, 1999).

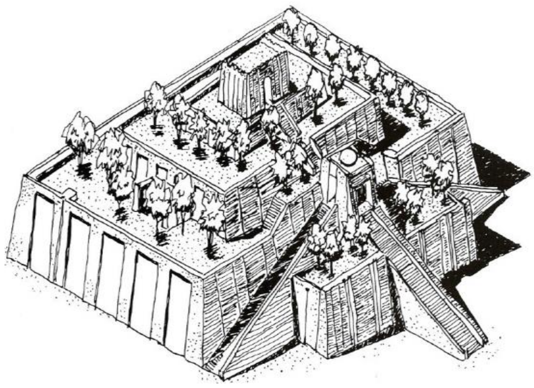
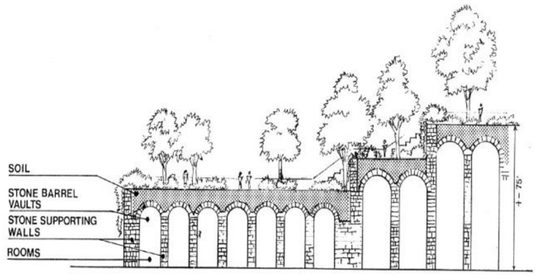
	

Figure 2.14: This section drawing of the Hanging Gardens of Babylon, 500 B.C. is based on the archeologist Robert Koldewey’s descriptions. (Finkel, 1988, p.42)	Figure 2.15: This section drawing of the Hanging Gardens of Babylon, 500 B.C. is based on the archeologist Robert Koldewey’s descriptions. (Finkel, 1988, p.42)

Within this palace, The King erected lofty stone terraces, on which it closely reproduced mountain scenery, completing the resemblance by planting them with all manner of trees and constructing the so-called Hanging Gardens (Finkel, 1988).

The gardens were 100 feet long by 100 feet wide and built up in tiers so that it resembled a theater. Vaults were constructed under the ascending terraces, which carried the entire weight of the planted garden. The uppermost vault, which was the highest part of the garden, was at the same time on the same level as the city walls. The roofs of the vaults which supported the garden were constructed of stone beams some sixteen feet long and over these were laid first a layer of reed set in thick tar, then two courses of baked clay brick bonded by cement, and finally a covering of lead to prevent the moisture in the soil penetrating the roof. On top of this roof, enough topsoil was put to allow the biggest trees to take root. The earth was leveled off and thickly planted with every kind of tree. Since the galleries projected one beyond the other when they were sunlit, they containing many royal lodges. The highest gallery contained conduits for the water which was raised by pumps in great abundance from the river (Finkel, 1988).

Although classical writings described the gardens, no definitive proof of their existence has ever been found. Whether the gardens did exist is still open to question, but they nonetheless remain perhaps the most famous gardens in history.

2.4.1.2. Gardens of the Middle Ages and Renaissance

Palazzo Piccolomini, Pienza, Italy

The creation of one of the first and best preserved roof gardens of the Italian Renaissance can be credited to Pope Pius II. The pope renamed the town Pienza and hired the noted Florentine architect to create a new plan for the town, as well as to design its buildings. Today Pienza is almost exactly as it was in the mid fifteenth century, with a town square surrounded by a fine cathedral, places for cardinals and a campanile (Finkel, 1988).

Pienza is built on a ridge, its terrain drops away on both sides. Hence, the outer buildings were built along the slope of the ridge with lower floors going downhill, below ground and the main floors at street level. After passing through the courtyard on the main floor, beneath the open arches that support the second floor above, one reaches the garden at the rear of the building which also seems to be at ground level (see figure 2.16). It is however, built mostly on the roof of a structure resting more than a full story below the main floor of the palace. This structure is constructed of massive stone and contains four rectangular rooms perpendicular to the rear wall of the palace. About two-thirds of the formal garden above rest on masonry edifice. The garden was the scene of much activity, as the pope greatly enjoyed holding audiences there. Today the garden, with its well-tended boxwood parterres and central fountain, is seen only by tour groups under the watchful eye of a guide (see figure 2.17).

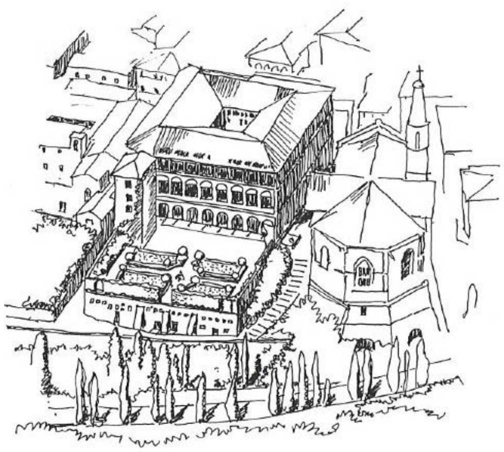
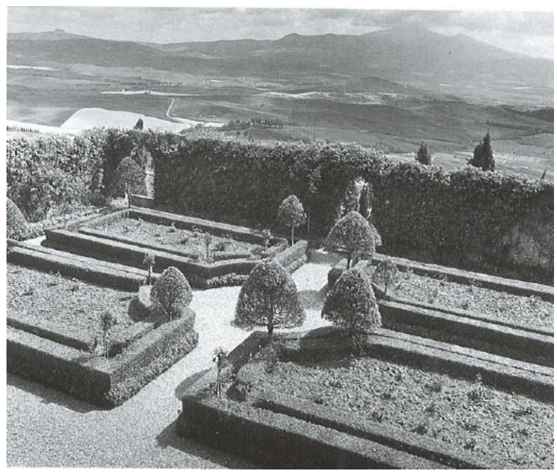
	

Figure 2.16: This aerial sketch of the Palazzo Picclomini in Pienza, Italy illustrates how the roof garden was built a top a structure that steps down the slope of a ridge. (Finkel, 1988, p.47)	Figure 2.17: The roof garden of the papal palace in Pienza looks out over the valley of the river Orcia, with Monte Amiata in the distance. (Finkel, 1988, p.47)

2.4.1.3. Roof Gardens From 1600 to 1875

Sod Roofs

To withstand their long, cold winters, Norwegians devised methods for living under extreme conditions centuries ago. One of these methods was the sod roof, a roof covered with soil for insulation that was planted with grasses and other plants to stabilize the soil (see figure 2.18). It was necessary to devise a roof section to hold the soil in place properly and to allow good drainage to prevent the roof from rotting.

With modern heating systems, this practice has practically disappeared in much of the country today, but a number of these sod roofs remain in the rural regions of Norway. The grass provided some stability to the bricks during handling and while they settled into place. The roof slightly overhung the walls to protect them from erosion by rain. The roofs made of growing sod, provides insulation (see figure 2.19).

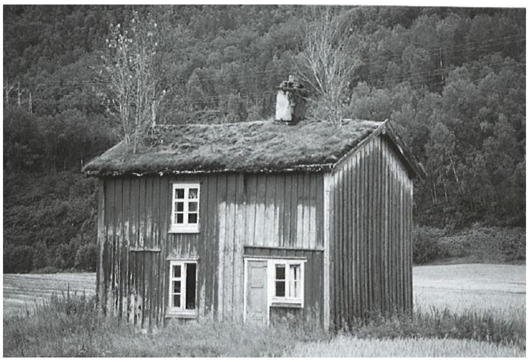
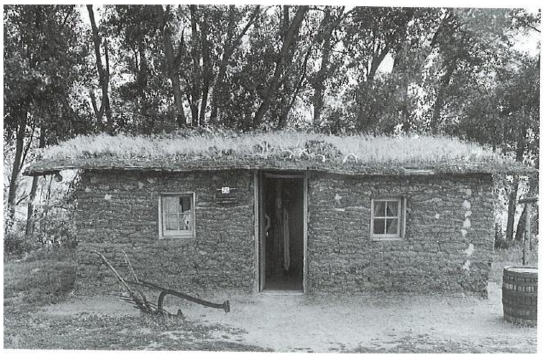
	

Figure 2.18: Both farm buildings and homes in Norway have been roofed with sod for centuries, and the custom persists still today. Even a tree has taken root in the roof of this Norwegian House. (Taschen, 2004, p.73)	Figure 2.19: Sod houses like this exact reproduction in Gothenberg, Nebraska. (Taschen, 2004, p.73)

2.4.1.4. Roof Gardens From the Turn of the Century until World War II

Almost forgotten today is the highly successful use of rooftops for summer entertainment in major cities throughout the United States and Europe. A green roofs appeared on mix-used buildings in Chicago. The main aim was to create recreational facilities to theatres for multi-functional purposes. A number of theaters use them as ‘winter gardens’ to this day. Levinson (1992) mentioned that the only way to overcome the high land costs of the inner city was to design the roof of a new winter theater to accommodate a summer outdoor garden theater. Like those that followed, the Casino theatre's roof garden was used throughout the summer. It had a partial sliding-glass roof to protect the performers and the audience from the rain (Rogers, 1974).

The theatres offered brightly lit stage entertainment, from the disreputable variety shows with an alternative to the mix-use buildings. At the peak of theatre popularity, green roofs entertained audiences during the summer. They were generally open to the sky, while they were constructed by predominantly glass structures, with or without sliding roofs, to allow use of the facility during rainstorms. The plantings, palms, ivy and others in containers were carefully positioned on the roof for maximum effect, as wells as to provide plenty of room for seating and tables for the audiences (see figure 2.20 and 2.21).

With, the introduction of air conditioning, and the changing tastes of the theater-going public, the final demise of the roof gardens came in the 1920s. They eventually closed, one by one and their buildings were demolished (Prescott, 1966). Although relatively short in duration, the popularity of roof garden theaters very likely inspired the development of future roof gardens.

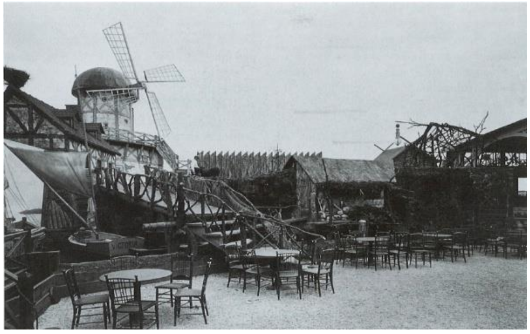


Figure 2.20: The Paradise Roof on Hammerstein's Republic Theater featured a Dutch windmill, a rustic stream with a bridge. (The Museum of the City of New York, The Byron Collection, 1999, p.125)	Figure 2.21: Oscar Hammerstein's Olympia Music Hall was one of the largest roof theaters of the late 1800s. (The Museum of the City of New York, The Byron Collection, 1999, p.125)

2.4.1.5. Green Roofs in Modern Times

Although their architectural philosophies were radically different , two of the most influential architects of the twentieth century, Frank Lloyd Wright and Le Corbusier, both designed buildings that incorporated roof as functional space. Wright included roof areas as extensions of the interior function. According to designer's inspirations were not true gardens, although minimal planting was incidentally included (see figure 2.22 and 2.23). Charles-Edouard Jeanneret, known as Le Corbusier, the Swiss architect and design philosopher, strongly embraced the use of roofs as living areas. Indeed he included roof terraces as on of the elements of the five tenets of modern architecture. Although, he focused on the roof which was an integral part of the architectural philosophy, he did not go so far as to recommend that the roof deck planted as a garden; rather, he considered the roof to be an exterior room, a place to be within and to look without. Giedion (1941) described that the intent of roof terrace space as the city dweller whom it was designed wanted to look out over the countryside rather than be set down among the trees and shrubbery. Le Corbusier wanted to enjoy the view, the breezes, and the sun to experience that unherited natural freedom which architect's work deprived. An examination of the roof deck of Villa Savoye reveals built-in raised planters for permanent greenery on the roof (see figure 2.24 and 2.25).

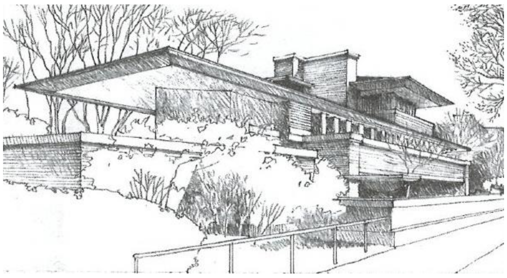
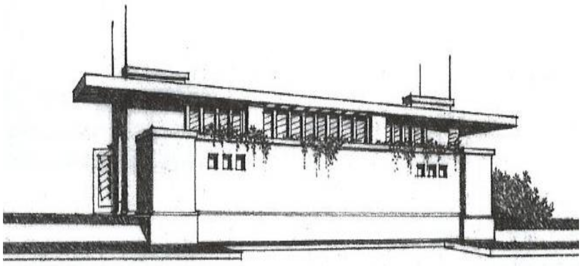
	

Figure 2.22: Robie House, Chicago, 1909, Frank Lloyd Wright.(Wright, 1960, p.57)	Figure 2.23: Project for Yahara Boat Club, Madison, Wisconsin, 1902, Frank Lloyd Wright. (Wright, 1960, p.93)

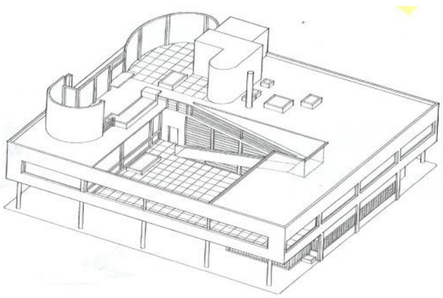
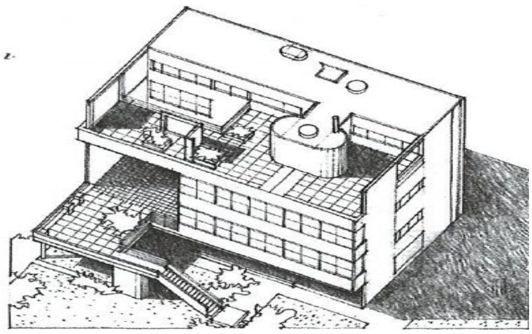
	

Figure 2.24: Villa Savoye, Poussy, France, 1928-31, Le Corbusier. (Le Corbusier, 1967, p.47)	Figure 2.25: Villa Garches, Vaucresson, France, 1926-27, Le Corbusier. (Le Corbusier, 1967, p.81)

2.4.1.6. European Green Roof Policies

European cities have been pioneers in the areas of urban ecology and urban greening, with many instituting impressive programs to support, encourage and plan for green roofs. Many European cities either mandate or subsidize green features in new urban developments and in the retrofitting of existing urban areas by the installation of ecological or green rooftops. In many Dutch, German and Austrian cities there have been long standing green rooftop programs. In Linz, Austria, for instance, one of the most extensive green roof programs in Europe, the city often requires building plans to compensate for the loss of green space taken by a new development, and the green roof has been one common response. This city, like many others in Europe, also provides a subsidy for retrofitting existing rooftops with a green roof. The Academy of Urbanism research (2010) concluded that paying up to 35% of the cost for installation, the programs have been quiet successful with hundreds of green roofs scattered throughout the city (see figure 2.26).

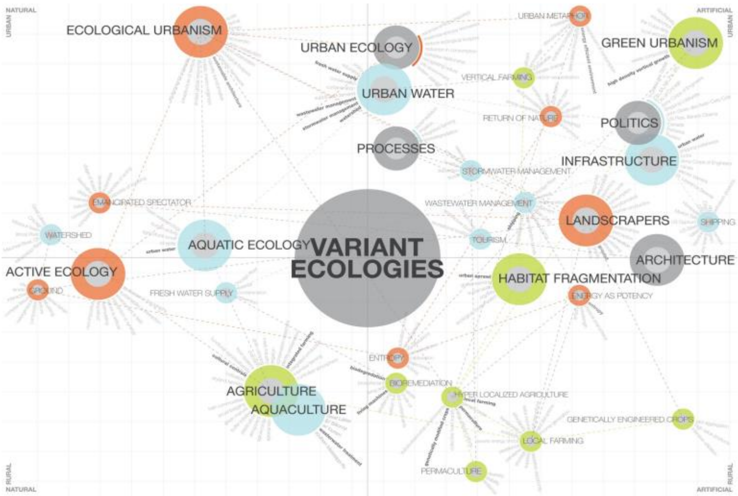
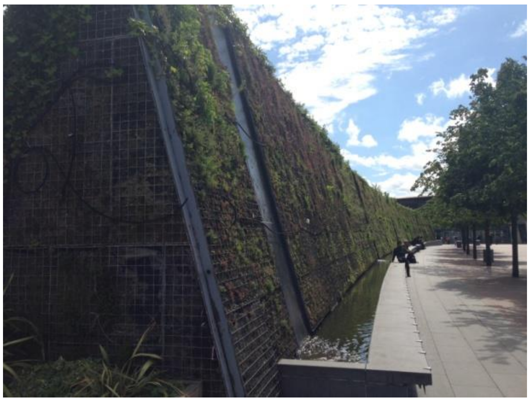


Figure 2.26: The mapping of European Green Roof Policies.

For example, Germany is considered as the world leader in promoting green roof technologies, where over 10% of houses installed green roofs (Zhang, 2011). Green roof applications are also common in other European countries such as France and Switzerland. In Portland (United States of America), several incentive programmes have been launched to encourage the construction of green roofs on buildings (Liu, 2005). In the United Kingdom, green roofs are used in built up city areas where residents and workers often do not have access to garden or local parks (ibid), (see figure 2.27 and 2.28). Schofield (2010) also mentioned that despite the innovative sixty-nine thousand-square-foot sloping green roof on the 1984 landmark sports and concerts arena Palais Omnisports de Bercy, the proportion of green roofs in Paris remains limited and Paris is lagging behind compared to other European cities. Ninety public buildings are covered with green roofs, totaling 36.000 m2 (Lagedec, 2010). About 20.000 m2 of these were added between 2007 and 2009, and ten additional projects are planned. A census of the roofs that could be planted estimates Paris's green roof capacity to be 314 hectares that is, 1.15% of suitable roofs are planted (Ville de Paris, 2010).

	
Figure 2.27: Student Accommodation, University College London, London. (Ozarisoy, 2013)	Figure 2.28:Novotel,Paddington, London (Ozarisoy, 2013)

Many other innovative urban greening strategies can be found in these cities, from green streets, to green bridges, to urban stream day lighting. Integrating such green features into city buildings can take many creative forms. Green walls can offer similar ecological benefits to green rooftops, and here as well Europeans have been leading the way (see figure 2.29 and 2.30). These structures cool the urban environment, retain storm water, reduce energy consumption and provide important habitats for birds and invertebrates. Depending on their location, they may be more visible and serve to enhance the greenness of cities.

	
Figure 2.29: Westfield Shopping Mall, Shepherd Bush, London.(Ozarisoy, 2013)	Figure 2.30:O2Arena Square, Greenwich Peninsula, London. (Ozarisoy, 2013)

In this chapter the definition of green roof, the role of green roof, space strategy for green roof, landscaping for green roof, history of landscape and European green roof polices have been discussed. The following chapter examines on green roofs on different building types: underground buildings within connected podium, office buildings, hotels and residential buildings. The design element of green roofs are examined to understand the green roof strategy.

2.5. Space for Green Roofs

Green roofs should be built only on the roofs of buildings that are structurally strong enough to support them. However, in the past some stone buildings with arched masonry ceilings in the rooms below were capable of supporting flat surfaces above, upon which roof gardens were built. For example, the garden at Pienza Italy, (see figure 2.31 and 2.32).

	
Figure 2.31: The cloister garden at Palazzo Piccolomini, Pienza, Italy, on the highest level of the monastery, rests on a chamber below. (Osmundson, 1999, p.102)	Figure 2.32: Gardens were installed at Palazzo Piccolomini, Pienza, Italy, wherever space was available. This small garden overlooks the gulf. (Osmundson, 1999, p.102)

Roof gardens more ideally suited to steel frame and reinforced concrete structures, on which strong support platforms can be provided at reasonable cost. With the technological advances in this type of construction over the last fifty years, such gardens have been built on top of many types of structures (see figure 2.33).

Figure 2.33: The diagram of the spaces of green roofs.

In general, green roofs are used for underground buildings within connected podiums, office buildings, hotels and residential buildings. This section will discuss on integrated green roofs because the scarcity of land and habitat loss lead to designer's create vegetated spaces. This green strategy reduces carbon emissions and urban heat island effect and also provides social areas for residents.

2.5.1. Underground Buildings

The development of green roofs, in the form of parks or plazas, on top of underground parking garages has become common place. Indeed, such multiuse development can often justify the purchase of land for its open space, which would be too expensive if purchased for that purpose alone. Parking fees then cover the expense of the garage as well as the installation and maintenance of the garden on the roof. Pioneering examples of such gardens include Union Square and Portsmouth Square in San Francisco and Mellon Square in Pittsburgh (see figure 2.34 and 2.35).

	
Figure 2.34: The roof of the parking structure for the Utah State Capitol and its offices was developed into a park, with a living map of the state as its central feature; Karsten, landscape architect. (Parma, 1977, p.122)	Figure 2.35: The garage for the Prague Inter Continental Hotel is located in front of the building. To avoid placing mechanical structures in the plaza at the entrance to the hotel, a raised planted area was built a top the roof of the garage. (Parma, 1977, p.122)

A roof garden can also contribute to the renewal of an urban area, particularly if it is designed in conjunction with another project. For example, underground parking spaces to ensure their success. Instead of simply including a parking lot or garage on or near the site, planners can incorporate a roof garden or plaza on top of an underground garage. Such an addition increases the value of the parking area itself and the project with which it is associated, enticing visitors to stay longer and convincing retail merchants and business to locate near the project. The result is an increase in tax for the municipality and greater business volume and revenues in the neighborhood. For example, San Francisco's Yerba Buena Gardens, with convention centers and San Francisco's Ghirardelli Square, (see figure 2.36 and 2.37). These are but a few of the roof gardens that have played role in both reclaiming a dilapidated city neighborhood and attracting visitors to a nearby project. Initially, this green roof icon generated some fear in the real estate sector, where it was seen as a corset around the city, a restriction on future urban growth.

	
Figure 2.36: The garden can also be entered via stairway to the street as well as from the office buildings surrounding plaza. (Tompkins, 2004, p.48)	Figure 2.37: A view of Mellon Square from above. The placement of heavier elements above the structural columns is clearly visible. The diamond paving pattern visually links the various part of the space. (Tompkins, 2004, p.48)

Historical or environmentally sensitive sites often require special consideration when buildings are added to them. One technique which architects have used to preserve such sites, is underground or earth-sheltered building. These structures can be configured in a number of ways. Earth sheltered buildings are frequently built into the sides of slopes. They have been successfully constructed, using cut and cover techniques, as well as by underground mining. Underground buildings are ideally suited for functions that do not require much human oversight, such as parking garages and storage facilities. But this technique has also been used for libraries, schools and convention centers. Although many earth sheltered buildings are not covered with plantings, their roofs can become roof gardens, often planted in such a way that garden camouflages the building, blending it into its site. Such roof gardens help to preserve the character of the site. Smithsonian Institution research (2005), exemplify the successful incorporation of a building into its historically sensitive through the use of underground construction and green roofs (see figure 2.38).

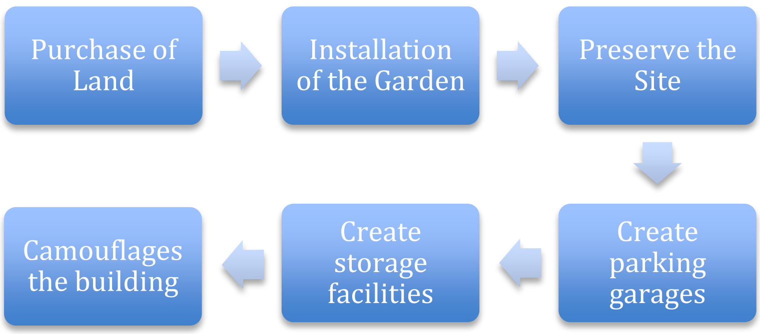


Figure 2.38: The advantages of green roofs in underground buildings.

2.5.1.1. Connected Podiums

A green roof can be singular, or it can be multiple. The most noticeable green roofs are those that serve as the elevated forefront of a single building. This concept has been expanded to produce connected green roofs, located just above street level, on high rise buildings that often have different owners. Such green roofs are linked by bridges over adjacent streets (see figure 2.39 and 2.40). The interiors of the buildings open directly onto the elevated roof decks, which lead to other roof decks, forming a gigantic podium level designed for human use and enjoyment.

	
Figure 2.39: Connected-podium roof gardens are a modern development in which roof gardens are connected by bridges over streets in San Francisco's Embarcadero Center. (Johnson, 1981, p.224)	Figure 2.40: The roof gardens then become one long podium above street level, as shown here in San Francisco's Hartford's Constitution Plaza. (Johnson, 1981, p.224)

The first appearance of this concept seems to have been of Rockefeller Center in New York, one of the first building complexes developed in a modern, highly dense central city. Although its entire open space at street level is on the roof of a vast underground concourse, its garden glory is the series of green roofs on top of four towers (see figure 2.41 and 2.42). These towers are separate, but their original plan was for the towers to be linked by bridges above the streets.

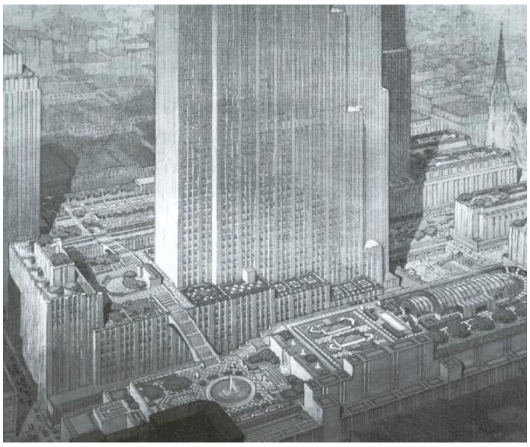


Figure 2.41: Early renderings of New York's Rockefeller Center show it was one of the first roof gardens planned with connected podiums. (The Great Rockefeller Group, 1996, p.93)	Figure 2.42: Constitution Plaza in Hartford, Connecticut, one of the first connected podium roof gardens, comprises a number of discrete spaces linked by walkways. (Osmundson, 1999, p.34)

The idea of connecting roofscapes is a modern one, growing from the close proximity of new buildings in the city core (see figure 2.43). It is interesting to note that The connection of large developed roof spaces offers a whole new opportunity for the development of usable open space for people in crowded urban areas (Osmundson, 1997).

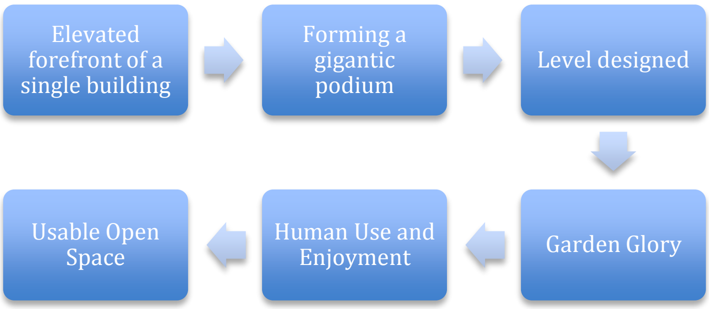


Figure 2.43: The advantages of green roof in connected podiums.

2.5.2. Office Buildings

The green roofs of office buildings are designed for a variety of users, for different puposes. Some, with restricted access, are reserved solely for the private use of executives, while others are open to all building employees and visitors, some even to the public at large as a space for eating, socializing and relaxing. Because the green roofs share structural space with a workplace, consideration must be given to separating the recreational activities of the green roof from the conduct of business, to avoid conflict, particularly when the public has unrestricted access to the roof (Southard, 1968). Green roofs associated with office buildings may be many stories above the ground or they can be at or just above ground (see figure 2.44 and 2.45).

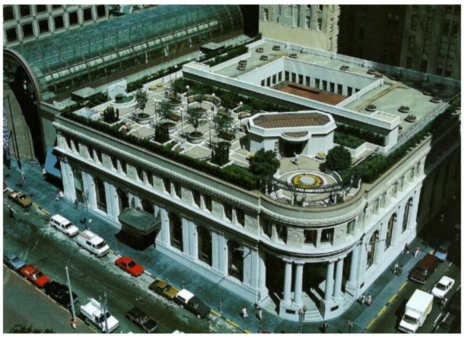
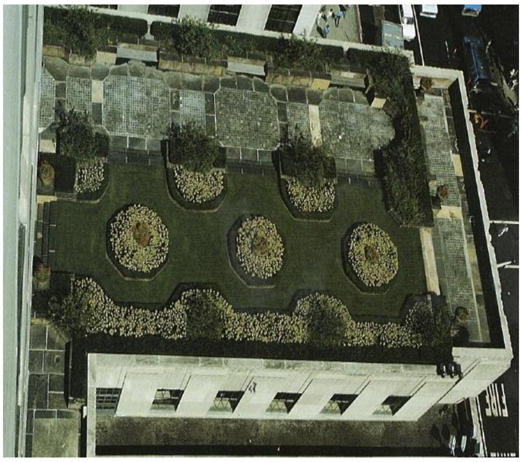


Figure 2.44: Access to the roof garden is primarily via an elevator from the street level bank entrance. The strong pattern created by the paving, plantings, seating and structural elements are clearly visible here. (Weyer, 1993, p.250)	Figure 2.45: Emerging from the elevator, one encounters a small plaza with a sundial and trellis. (Weyer, 1993, p.250)

Green roofs on top of office buildings may also serve solely as a visual amenity, where the drab ugliness of roofs with their glut of vents, pipes, mechanical equipment and storage would detract from the value of any interior space that looks out onto the roof. In addition, such green roofs, especially those with strong planting patterns, offer a pleasant alternative to the usually unattractive views of urban roofs from neighboring buildings. The green roofs on top of Rockefeller Center is one of the most well known examples of this type of green roofs (Sutro, 1992), (see figure 2.46 and 2.47).

	
Figure 2.46: Close-up views of the gardens of La Maison Francoise, Rockefeller Center, New York. (Murbach, 1999, p.67)	Figure 2.47: Close-up views of the gardens of the Plazzo d'Italia, Rockefeller Center, New York. (Murbach, 1999, p.67)

Roof gardens associated with office buildings provide a place for employees to mingle in a more relaxed setting. Public roof gardens serve a myriad of community functions, as a space to meet, to socialize, to attend special events. In the suburbs, ground level parks, plazas and gardens could fill such needs, but in built up cities, roofs are often the only space available (see figure 2.48).

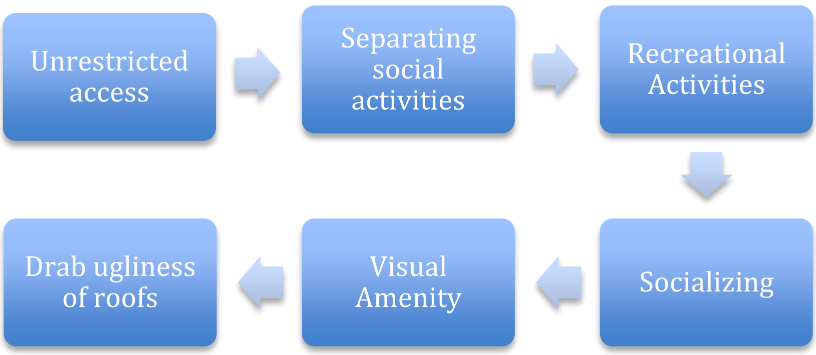


Figure 2.48: The advantages of green roofs in office buildings.

2.5.3. Hotels

Hotel owners in the United States and all over the Europe soon recognized the value of their roofs in providing space for outdoor gardens that could also be used for parties, special events, dining and other activities. Today new hotels in the cities can again boast of rooftop decks or terraces rivaling the quality of any green roofs (see figure 2.49 and 2.50).

	
Figure 2.49: The Hilton Palacio del Rio in San Antonio, Texas, built its roof garden a top the entry portico. (Arpa, 1993, p.256)	Figure 2.50: Shade structures and well designed planning areas make the roof garden a top the Hilton Palacio del Rio in San Antonio a popular space for cocktail parties and small receptions. (Arpa, 1993, p.256)

The most obvious advantage of a roof garden is that it is a as a valuable amenity that enhances the worth of the structure it occupies. The building owner can charge higher rates for rental space because the garden is an addition. Similarly, hotel owners can charge more for buildings with roof gardens and for rooms with direct access onto and views from roof gardens. Businesses that own or rent space in a building with a roof garden can showcase the garden as an additional amenity for employees as well as an area to entertain clients (see figure 2.51).

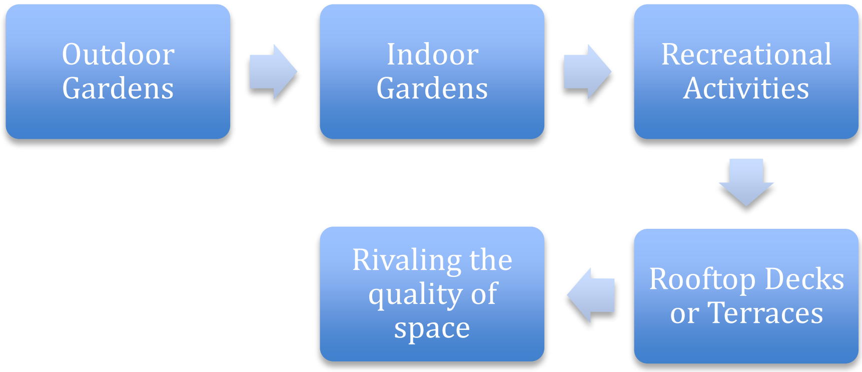


Figure 2.51: The advantages of green roofs in hotels.

2.5.4. Residential

As America’s and Europe’s suburbs continue to multiply, so to do most common manifestations of the green roof, the ubiquitous suburban deck and garden apartment balcony (see figure 2.52 and 2.53). Though usually not on top of true roofs, vegetated space on a deck or apartment terrace require some of the same considerations as green roofs do, on a smaller scale: plants are container grown, furnishings are essential, loads are a concern, access must be convenient, orientation affects both user comfort and plant survival and maintenance must be provided. The economic benefits relating to ecological planning are widely recognized. The greenbelt has helped the image of areas nearby, and it is clear that real estate promoters have improved their sales by taking advantage of the proximity of their new buildings to these natural spaces (Gauzin, 2006).

The small scale of such green roofs, however, eliminates some of the major concerns common to the larger green roof: irrigation and fertilizing are simpler, soil is generally not in contact with the structure, waterproofing is usually not part of the deck structure and plantings are generally less extensive and more easily replaced.

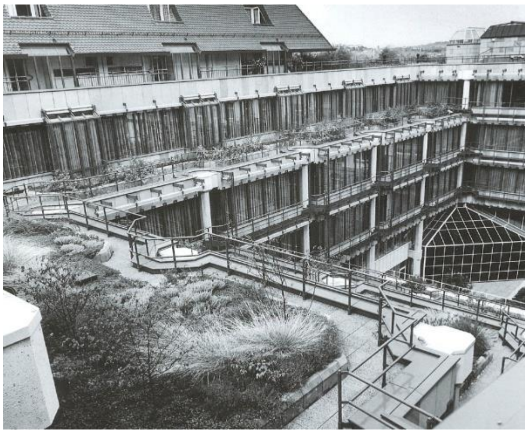


Figure 2.52: This roof garden on the Allianz building in Stuttgart, Germany is one result of that city's effort to green its roofs. (Osmundson, 1999, p.73)	Figure 2.53: Small terrace and deck gardens, like this one outside a New York City apartment, are roof gardens on a smaller scale. (Osmundson, 1999, p.73)

Residential gardens on top of apartment buildings bring together neighbours whose only other contact might be a brief nod in an elevator. More in keeping with the traditional notion of green roofs is the community garden on top of urban apartment building. Such a roof may be ornamental, designed as a comfortable place for residents to use as an outdoor room. More commonly, however, these green roofs are productive vegetable or herb gardens planted and maintained by resident gardening enthusiasts in the building (see figure 2.54 and 2.55). The recent trend promoting the use of the freshest vegetables and herbs has made such rooftop gardening quite popular in urban areas, where the lack of available space precludes ground-level gardening. Because green roofs rise above nearby buildings and trees, they generally receive more sunshine than ground level plots, a condition necessary not only for plant growth and the production of vegetables, but for the comfort of the gardener as well. Such green roofs offer an easily accessible, private area that can also provide pleasant opportunities for social contact with others who have a common interest in growing plants (see figure 2.56 and 2.57).

	
Figure 2.54:Round Skylights punctuate rows of neat vegetable and flower beds on the roof, allowing sun to filter to the interior space floor below, Gary Comer Youth Center, Chicago, Illinois. (Shigley, 2009, p.54)	Figure 2.55: Roof top community garden provides social areas for users, Gary Comer Youth Center, Chicago, Illinois. (Shigley, 2009, p.54)

Figure 2.56: The rendering of New York Rooftop School Gardens, New York. (Handel Architects, 2009, p.51)

Figure 2.57: The rendering of New York Rooftop School Gardens, New York. (Handel Architects, 2009, p.51)

Shared gardens are one of the important factor which brings neighbours together for a variety of activities that go beyond the act of cultivation. These spaces, whether formal allotment gardens are increasingly seen as vehicles for forming and strengthening communities, as well as sites for sharing knowledge, learning and leisure. Many recent examples of gardens related structures, and organizations that support community through gardening and similar institutions emphasize the role of design and designers in strengthening the contribution of food production to building a community and knowledge in cities (see figure 2.58).

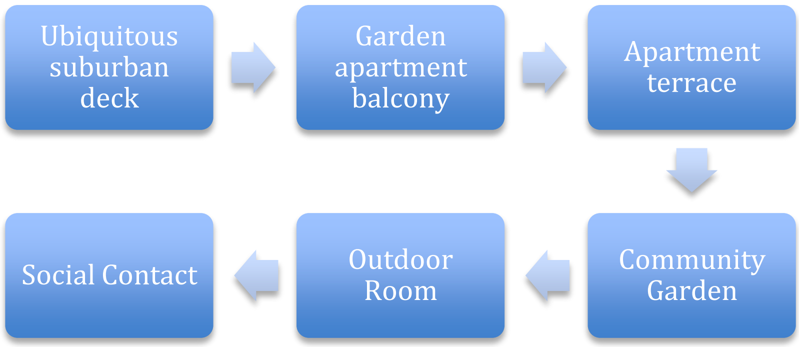


Figure 2.58: The advantages of green roofs in residential buildings.

In this chapter initially theoretical information discussed on green roof then, the role of green roofs, space strategy for green roof, landscaping for green roofs, history of landscape then follow up spaces for green roof within the building types examined on. According to this deeply theoretical research demonstrates that green roofs are designed to increase the livability and architectural aesthetics of space. The landscape architecture is also the main part of green roofs, which has already discussed above. This research also supported by history of landscape to understand the importance of landscape architecture on green roofs. The next section will be discussed design elements of green roofs to demonstrate their design requirements and construction systems.

2.6. Design Elements

The variety of design elements that can be used in a green roof. Almost anything that can be installed on the ground can be included in a roof garden. This section will examine on some of the more common features of green roofs as well as offering suggestions for choosing and installing them. A sense of the range of design features available can also be gained by examining the portfolio of green roofs (Appendix A

Table 1 to 8).

This section will examine on design elements of green roofs in terms of plants and planting, plant containers, roof patterns, roof paving, furnishings, lighting, sculpture and water features, windscreens, shelters and other structures (see figure 2.59).

Figure 2.59: The methodology of examining green roof design elements.

2.6.1. Plants and Planting

Green Roofs must constitute various types of plants. The intensive green roof should be able to support a whole range of plants, from lawns, ground covers, perennials and annuals to shrubs and trees of considerable height. Such a combination requires consideration of weight, soil, depth, drainage, ultimate height, ultimate spread of roots and crown type and extend roof system, resistance to drought and overwatering, potential life span, the mix of plant types and ease or difficulty of replacement.

Categorizing individual plants according to their suitability for green roofs would be a gargantuan task, undertaken largely in a vain. Each garden has its own particular requirements with regard to function, microclimate and climate, soil, water availability, cost maintenance and aesthetics. For example, plants that are ideally suited for a small private garden in San Francisco might not survive six months in a public garden in Boston. Moreover, a plant that has some disadvantages might nevertheless have more important strong points that make its choice appropriate. For example, although crab apples can be messy trees that drop both flowers and fruit, their small size, quick maturity, hardiness and ornamental nature might supersede their weakness in a particular space. Landscape architects should consider the necessary characteristics of trees, shrubs and plants in green roofs that will be describe below and then apply this information in determining plant selections that are appropriate for a particular green roof design in a specific location. Local consultants or county extension services can provide advice on choosing species well suited to a site’s climate.

On a green roof, ground covers, lawn and ornamental annuals and perennials are chosen using essentially the same criteria as in ground level gardens (see figure 2.60 and 2.61). Trees and woody plants require more careful consideration, for they should be longest-lived and are the most costly. They also weigh the most, require the most adaptation to roof garden settings, and have the strongest visual effect in the garden. Characteristics to be considered when choosing the plants include root invasion and penetration of the membrane, excessive leaf and fruit drop, selfseeding, reaction to acid and alkaline soils, resistance to drought and tolerance for overwatering, surface rooting, acceptance of root pruning and ability to survive drying out or freezing of roots.

	
Figure 2.60: This inviting garden, with three separate seating areas, offers an excellent view of Boston's harbor. Federal Reserve Bank, Boston, Massachusetts. (Robert Fager, The Stubbins Group, Boston, 1999, p.21)	Figure 2.61: The interior-court design comprises dwarf evergreen shrubs, large pebbles and raked pea gravel in the Japanese style. Federal Reserve Bank, Boston, Massachusetts. (Robert Fager, The Stubbins Group, Boston, 1999, p.21)

In this section initially theoretical information has also discussed on plants and planting then this section will also explain types of tree, size of trees, weight of trees, fruit and leaf drop of trees, soil depth of trees to understand their design and construction principles.

2.6.1.1. Types of Trees

Some trees are well known for their invasive root habits. For example, poplars, willows, alders and sweet gums are notorious surface feeders that will seek out any water source within their reach and beyond. Many woody shrubs also have invasive roots. Such plants will quickly fill a planting bed with roots, draw down the water supply of other plants and generally dominate the planting. Trees with invasive root habits will also likely seek out openings in water proofing, where water has penetrated the membrane. Roots may also compromise the membrane themselves if the membrane contains organic material that the roots can feed upon, as it the case with built-up asphaltic roofs. Although inclusion of barriers to root penetration in the green roof design can eliminate these problems, for extra safety as well as to ensure the survival of all plants in the vicinity, trees and shrubs with invasive root habits should be avoided (Zion, 1986).

2.6.1.2. Size of Trees

The height of tree’s grown and its spread in relation to the spread of its roots are important characteristics to consider to prevent the tree from overturning in high winds. A tree planted with soil mounded up to the top of the root ball, so that the surface gradually slopes away to a flat area of a foot or more in depth, will develop a suitable root flange that anchors it to the garden. A wide roof flange is the best means of preventing wind throw; however limited space may prevent adequate root spread. The tree should be left in place permanently, allowed to rot away underground as the roots grow horizontally and tree matures. Two such methods of bracing are shown in figure 2.62 and 2.63).

Figure 2.62: The center of the garden is highlighted by a low overlook onto a pond with water jets, which can also be viewed from a walkway and ramp that bridge it. Union Bank Square, Los Angeles, California.(Harrison and Abramovitz, 1999, p.60)

Figure 2.63: The garden occupies the entire roof of the large underground garage, beneath the continuous podium of the building. Union Bank Square, Los Angeles, California.(Harrison and Abramovitz, 1999, p.60)

Although inadequate soil depth and area can restrict a tree's root system and thus prevent it from attaining full size, tall species should not be planted on roofs. Such trees, even when stunted by a limited root system, are susceptible to wind throw, exceed weight limits, and appear oversized. A reasonable should be from 3 to 4.5m for small trees and 6 to 7.6m for the largest. In most roof areas close to buildings, these sizes appear to be in a good scale relative to their surroundings (Truex,1969).

2.6.1.3. Weight of Trees

When the weight of mature tree is computed, it should be remembered that weights on roofs are figured as concentrated loads, that is, in weight per square foot at each contact point on the roof. The root system and tree's superstructure grow out ward, the overall weight will be spread out over a larger surface area. It is even possible that the point load weight of the tree could decrease as the tree grow, if it has enough horizontal area over which its roots can spread (see figure 2.64 and 2.65).

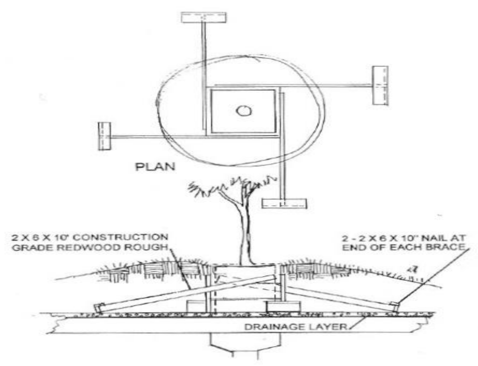
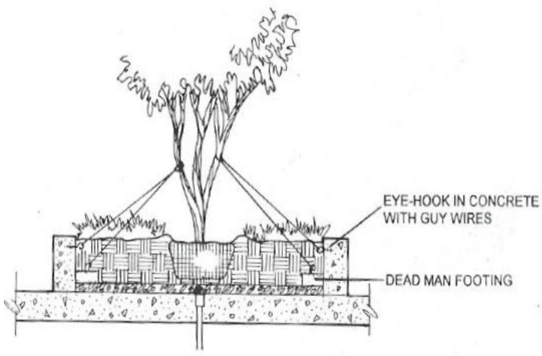
	

Figure 2.64: Underground bracing of a tree to prevent guying. The wooden braces and tree box are allowed to root away, with root growth replacing them for support. (Osmundson, 1999, p.83)	Figure 2.65: Guying a bracing a tree aboveground to either a wall or underground. (Osmundson, 1999, p.83)

2.6.1.4. Fruit and Leaf Drop of Trees

All trees and woody shrubs drop fruit and leaves as a natural part of healthy growth. On roofs this is a concern only of degree and location. The inclusion of paved paths, patios, plazas, benches and similar hard surfaces in a design can make fruit drop a messy problem in green roof development. If possible, flowering plums, crab apples, cherries, ginkgos, olives and other heavily fruiting trees should not be planted near paving, furnishings and water features. Some fruits can permanently stain hard surfaces where they fall.

2.6.1.5. Soil Depths of Trees

The ultimate size of trees must be limited because soil depth is limited in green roofs. Where the overall depth of soil must be low, in the range of 15cm to 25.4cm, it is possible to mound soil higher over stronger points in the structure, such as columns, to depth of 76.2cm or more. Using raised beds, the bottoms of which dropped below the surface of the roof, can increase total soil depth to 1.5 m to 1.8m. Such an arrangement must be planned and designed as part of the building's architecture. For other areas where shrubs, ground covers and lawn but no trees are to be planted, depths ranging from a minimum 15cm for lawns rising to 61cm or more shrubs are possible to be planted to recover sufficient construction requirements (see figure 2.66 and 2.67).

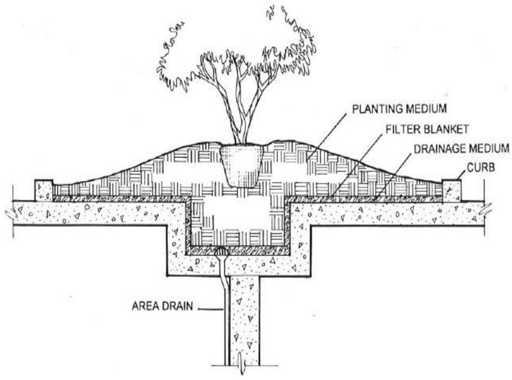
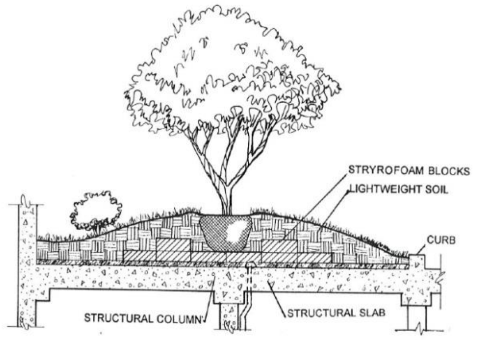
	

Figure 2.66: To increase soil depth, the roof below the tree can be lower than it is beneath other parts of the garden. (Osmundson, 1999, p.88)	Figure 2.67: Soil can be mounded around a tree to provide greater depths. The Styrofoam blocks reduce the amoun of soil needed, thus also reducing weight and cost. (Osmundson, 1999, p.88)

2.6.2. Plant Containers

Plant containers such as pots, tubs and boxes are used universally on decks, balconies and porches. They can also be indispensable on a roof that has a severe load restriction or has waterproofing that requires periodic replacement. In such cases, plant containers, though some can be quiet heavy, are often the only answer to having any planting at all. Even in green roofs with less stringent weight restrictions, plant tubs can have a very useful purpose in enhancing plant material as design accents, as temporary homes for colorful annual flowers and as places to grow flowering shrubs and trees that function as aesthetic variety of structural elements in non flowering seasons (Wagoner, 1998), (see figure 2.68 and 2.69).

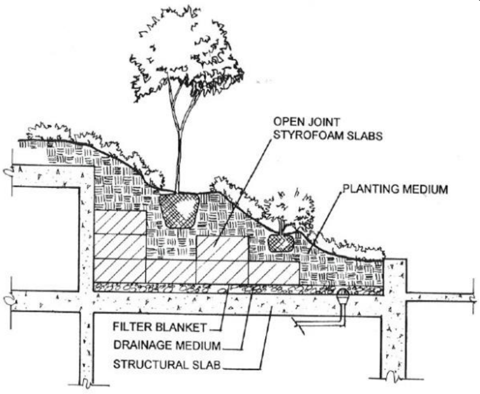
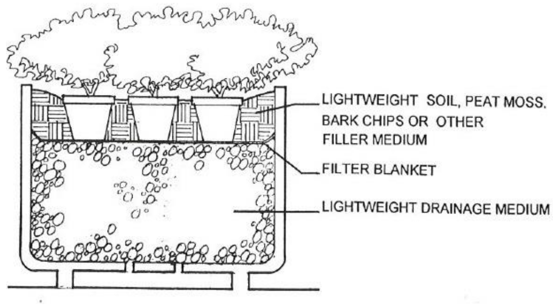
	

Figure 2.68: Styrofoam slabs below the planting medium can vary the soil depth, making a range of depths for a variety of plants possible. (Retzlaff, 2007, p.57)	Figure 2.69: The reduce the amount of planting mix used for potted flowering plants that are changed seasonally, small pots are grouped in a larger container. (Retzlaff, 2007, p.57)

It should be noted that stationary plant containers that remain in place year round are generally only appropriate in areas that experience mild winters. For example, in northern climes, freezing and the freeze cycle will cause many containers to crack, regardless of material. Plant containers have some of the same requirements as larger raised beds do. They should be able to retain moisture in the soil and yet have good drainage to prevent souring of the soil (Whalley, 1978).

2.6.2.1. Materials of the Containers

Unlike ornamental residential containers, which can be considered temporary, green roof plant containers should be considered permanent design elements and therefore should be as durable as possible. Replacement, particularly if irrigation piping has been installed, can be both difficult and costly. Concrete terra-cotta and UV resistant plastic containers last the longest and will retain their shape and color. Redwood, cedar and teak are durable but should be lined with copper or galvanized iron to prevent the inside of the container from rotting (Darbourne, 1968).

For example, in Europe, a system based on polystyrene containers is fairly popular. The roof system consists of lightweight polystyrene boxes that are approximately 17.8 to 35.5cm high. Their limited depth prohibits their use for large plants such as trees, but they are very useful for low ground covers or low shrubs (see figure 2.70 and 2.71). Their design is functional for mobility, drainage and extended storage of water for irrigation. The system is widely used for roof planting where access to the roof is limited to maintenance staff.

	
Figure 2.70: A planter along the plaza's edge contains perennials and vines climbing up the walls. Mayor Ogden Plaza, Chicago, Illinois. (Jacobs/Ryan Associates, 1999,p.104)	Figure 2.71: A small area near the building entrance is furnished with tables and chairs. Union Bank Square, Los Angeles, California. (Harrison and Abramovits, 1999, p.47)

2.6.2.2. Irrigation of the Plant Containers

There are few alternatives for supplying water to a plant container placed on ornamental paving during dry periods. The first is to have water piped to the container and brought up through the soil, where, it can be distributed by short throw sprinkler head. A difficulty with this method is in bringing the water to the plant without the pipe being visible on the pavement. If the container is to be placed next to a building wall, the pipe can be laid on the surface where the wall and pavement meet. The pipe can be seen but is not obtrusive. A connection or tee can bring the pipe under the container and up through the soil to its surface.

Recent innovations in container configurations have made container irrigation somewhat less difficult than before. The new system of irrigation, which relies on the transmittal of water via capillary action from reservoirs at the base of the container, is available for individual planters as well as raised beds. Another system is that there are plant containers are sold in range of sizes for use both indoors and outdoors. The planter and its water reservoir are integral. Water is held in the hollow walls of the plastic container itself, which is filled by opening an airtight cap on its upper rim. When the cap is replaced and tightened, a vacuum is created above the water level. When the soils become dry, a moisture sensor located at the upper root level of the plant connected by a tube to the vacuum chamber. The vacuum is reestablished, preventing more water from moving to the container (Scrivens, Stephen and Cooper, 1980).

2.6.2.3. Drainage of the Plant Containers

The difficulty with drainage in container planting is not the draining of the container, which is handled in the same way as a planting bed, but in dealing with the water after it drains from the container. Drainage itself is fairly straightforward. A layer of drainage material should cover the inside the bottom of the container. Polypropylene filter fabric should cover the drainage material on the upper, or soil, side. When the water leaves the container, it will drain onto the surface beneath and should flow to the nearest catch basin. If the container is on a paved surface or the route to the catch basin paved, decaying salts and other material in solution in the drain water will stain the paving. A simple way to prevent this problem is to install long lasting copper pan under each container. The pan should be deep enough to hold any excess water. It should be emptied regularly to ensure that it does not over-flow and that the water in it does not become a breeding place of mosquitoes (Robinette, 1968).

2.6.2.4. Wooden Planter Walls for Raised Beds and Containers

When less sophisticated gardens, such as community gardens are desired on building roofs, low wooden walls are often used to frame the planting beds, instead of the more typical brick, stone or concrete. The material is easily brought to the roof in the building's elevator. Although building codes generally prohibit the use of wood in steel –frame buildings, there seem to be some acquiescence in permitting this type of construction. The wood, for longevity, should be seasoned redwood or cedar wood that has been pressure treated with preservative. The walls may be attached to the roof, either with metal angle braces attached to the wall and protective concrete slab (see figure 2.72) or with concrete poured after the wall has been built (see figure 2.73). A drainage medium should be added before the beds are filled with planting medium. If the bed is large enough, the weight of the soil may be enough to hold the bed in place and the angle braces may not be necessary (MacDonald,1963).

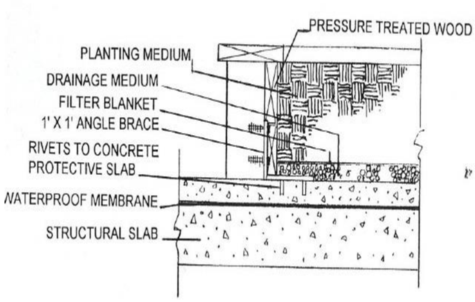
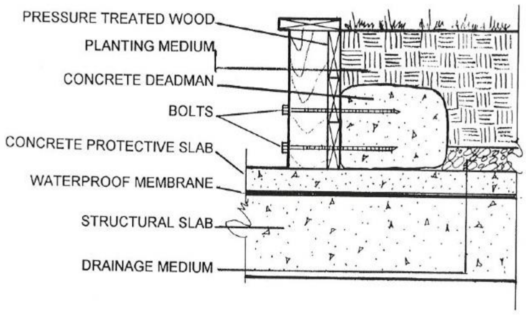
	

Figure 2.72: Angle braces riveted to the concrete protection slab are one means of supporting wooden walls for planting beds. (Southern Illinois University research, 2007, p.132)	Figure 2.73: Wooden container walls also be bolted to a deadman for support. (Southern Illinois University research, 2007, p.132)

2.6.3. Roof Patterns

The appearance of buildings with weak roofs and those that are unsuitable for gardens can be substantially improved by applying simple, permanent materials such as colored gravels. Gravel is very commonly used as ballast on flat built-up bituminous roofs to protect the membrane from ultraviolet light and physical wear, to prevent wind uplift of the membrane and to improve the membrane's fire resistance. When such roofs are lower than, and so visible from the occupied floors of neighboring buildings, they can be made more attractive by applying two or more colors of gravel in a planned pattern for almost the same cost as a single color (Schonolzer, 1968), (see figure 2.74 and 2.75).

	
Figure 2.74: Adjacent to the East Bay Municipal Utility District's offices in Oakland, California, this simple plant and gravel pattern provides a graceful transition between the employees' roof deck and the neighboring gardens below. (Basilico, 2008, p.268)	Figure 2.75: Only when viewed from above can the extent of the roof garden and the sensitivity of the site be fully appreciated. RMC Group Services International Headquarters, Surrey, Great Britain. (Basilico, 2008, p.268)

For example, patterns created from low durable ground covers, such as Sedum acre, a hardy silver green succulent, are also an alternative under some circumstances. These have been successfully used in Germany, Switzerland and other European countries (see figure 2.76 and 2.77).

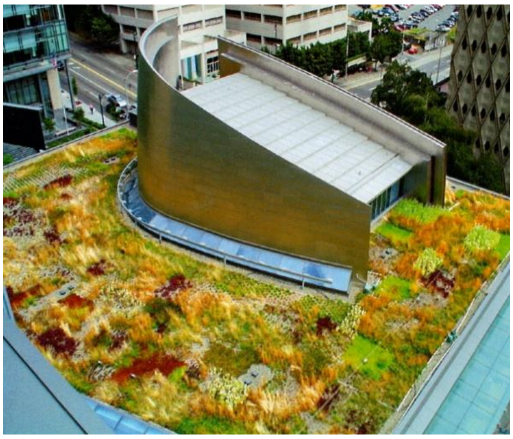


Figure 2.76: The roof above the civic plaza in the country of San Marino is covered with a pattern of trimmed perennials and other drought resistant plants. (Retzlaff, 2007, p.28)	Figure 2.77: The simple roof pattern was designed for the roof of elementary school in Bern, Switzerland, by Franz Vogel. The pattern is created mostly various colors of plants. (Retzlaff, 2007, p.32)

2.6.4. Paving of Green Roofs

Although hard surfaces on green roofs serve the same purposes as those in gardens at ground level, in at least two respects they deserve special attention. In most cases green roofs are viewed from the higher floors of adjacent buildings in highly dense areas. The appearance of paving thereby assumes a far greater importance and demands stronger and more careful design.

In addition, the amount of shade provided by trees on top of buildings is restricted by the lack of size and spread of mature trees in this artificial environment. If people are to sit outside in sunny areas, the paving must reflect a minimum of unpleasant glare. Plain concrete paving, for example, reflects considerably more uncomfortable glare than, say, red brick pavers do. Non-reflective paving choices are extensive and range from deep colored concrete to fine tile and brick (see figure 2.78 and 2.79). Colored concrete with deep colored exposed aggregate, cut flat field-stone, granite sets, concrete interlocking and sandstone are all non reflective. There are many variations within each of these general types of paving and the combinations of materials.

	
Figure 2.78: Kaiser Center, Oakland, California. (Welton Becket and Associates, 1999, p.65)	Figure 2.79:CaliforniaState Compenstation Insurance Building. (John Carl Warnecke and Associates, 1999, p.83)

On wood frame buildings with structurally weak roofs, removable pallets provide a good surface for furniture and potted plants. They are lightweight and allow access to the drains and membrane for repairs and maintenance.

Not recommended in public green roof is loose gravel, which if kicked about, can cause clean-up problems. Gravel is also an uncomfortable walking surface and it is difficult to maneuver wheeled vehicles. Dust on the surface of decomposed granite walks may be blown about by high winds. Asphalt is usually impractical or impossible to install because it must be rolled with heavy equipment to obtain its final finish; its use is feasible only if access is directly available from the street and weight limitations permit.

When choosing paving materials, particularly those for elevated gardens on existing structures, consider how they will be transported to the site. It is, for example, easier, cleaner and less expensive to transport bricks in an elevator in an existing building than it is wet concrete. In a building under construction, of course, cranes and exterior elevators are capable of lifting almost any materials equally well (Morgan, 1972).

2.6.4.1. Pedestal Paving of Green Roofs

It is sometimes desirable to use a system of prefabricated pedestals to mount paving squares or rectangles above the surface of the roof. Such paving units can be easily removed to repair or clean the roof surface below. Water enters the cavity formed between the paving slabs and is carried away via the sloping roof and drains (see figure 2.80 and 2.81). The insulation lies beneath the concrete slab. Pedestal should never rest directly on the waterproof membrane.

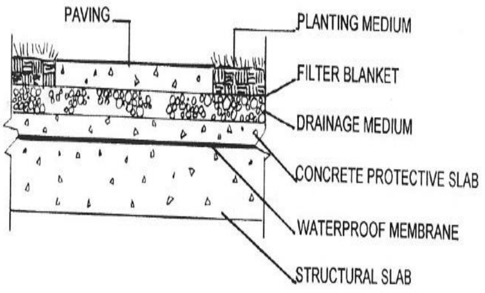


Figure 2.80: Concrete paving can be poured directly on the surface of a drain rock if filter fabric is placed as a barrier to prevent wet concrete from filling rock voids.
(Retzlaff, 2007, p.41)

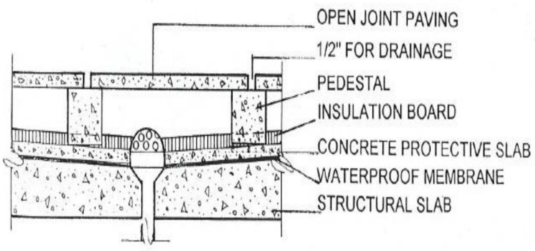


Figure 2.81: Paving blocks placed and leveled on permanent pedestals permit good drainage to the sloping roof below and protect the membrane from sunlight.
(Retzlaff, 2007, p.41)

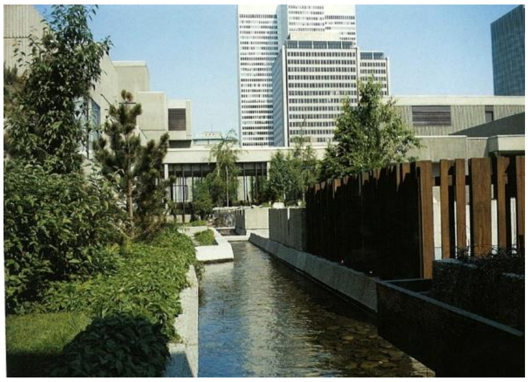
2.6.5. Furnishings

Green roofs should be well furnished and as comfortable to use as possible, as should privately owned gardens that are open to the public. For example, the green roofs of hotels, where access is somewhat limited, are almost universally well furnished, adding greatly to their use and guests enjoyment of them. To prevent vandalism or theft of furniture in a more accessible space, the garden might require the employment of a guard on duty during the garden’s visiting hours.

Furnishing should be weather resistant so that they can be left in place during warm seasons. Plastic covered steel or aluminum frames with an all weather coating are both very good. Wood furnishings, because of their bulk and weight as well as their easily located joints, are less desirable for public use. Umbrellas are almost a necessity in bright sunny spaces. A maintenance staff should be available on the premises to lower the umbrellas on windy days, so that they do not tip over.

If only permanent benches are to be provided, they should have arms, should have seat backs made of wood or resilient metal and should be designed to fit the contours of the back properly. With all the back troubles from which people suffer, there is no reason to settle for less in outdoor benches. A number of such well-designed benches are commercially available (see figure 2.82 and 2.83). Well designed trash receptacles and drinking fountains should be provided at convenient locations throughout the garden (see figure 2.84 and 2.85).

	
Figure 2.82: The patio deck, with the waterfall and building in the background. Kaiser Resources, Vancouver, Canada. (Heathcote, 2004, p.143)	Figure 2.83: The sheltered redwood deck extends over the pond. With its comfortable outdoor furniture and flowers, it is an ideal space for quiet conversation. (Heathcote, 2004, p.144)

	
Figure 2.84: The redwood deck and window washer setback, looking toward the machine’s garage. Tie-downs for the equipment are in the pawing and lawn. Kaiser Resources, Vancouver, Canada. (Goldberg, 2002, p.134)	Figure 2.85: In its early years, the garden, though densely planted, had not yet grown full, making continuous ever-changing stream the garden’s dominant feature. (Goldberg, 2002, p.134)

2.6.6. Lighting

A green roof is the least costly to light when lighting is planned during its design, so that electrical wiring can be installed during construction. Like the irrigation system, electrical conduits and the necessary junction boxes, outlets and other elements can be installed before the placement of the planting medium, eliminating the cost of digging or trenching later. At the general location where lighting is desired, the individual wiring and fixtures can be connected to the outlets and the lighting effect can be fine-tuned. The conduits are installed on the roof surface, hidden under the drainage and planting medium. If open plastic drainage and planting medium (Pellet, 1976).

Special attachments are needed for light standards on top roofs where the waterproof membrane should not be punctured. Path lighting with short standards can be attached to the concrete protective slab as shown in figure 2.86 and 2.87. A flanged pipe is attached to the slab with short bolts. Taller light standards that must resist the pressure of high winds require a strong attachment to the roof's structural slab (see figure 2.88 and 2.89).

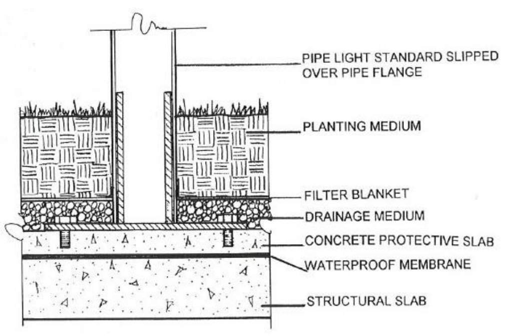
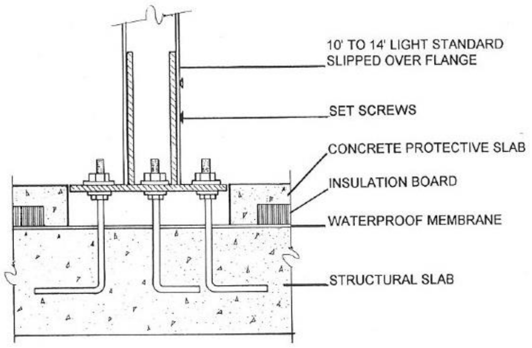
	

Figure 2.86: Light can be anchored to the concrete protection slab by attaching the flange with set screws or bolts to expansion shields in the concrete or by shooting bolts into the slab. (Smithson, 2004, p.91)	Figure 2.87: A pipe with flange placed on the concrete protection slab makes a firm base onto which a short light fixture can be fitted. Secure the low level light with set screws. (Smithson, 2004, p.91)

	
Figure 2.88: Mayor Ogden Plaza, Chicago, Illinois. (Osmundson, 1999, p.132).	Figure 2.89: Floating Grass Plain, Mercati di Traiano archeological site, Rome,Italy. (West 8, Rotterdam, Holland,2004, p.17)

2.6.7. Sculpture

Sculpture is an important feature in almost any garden and is especially useful to highlight a feature or create a focal point in green roofs (see figure 2.90 and 2.91). No practical reason prevents the use of such works of art except for the excessive weight of heavy pieces. If the green roof is designed before the building is built, the roof structure can be designed to receive such concentrated loads. Otherwise, care should be taken to asses the weight of the sculpture and, if necessary to locate the piece over a column or other strongly reinforced part of the roof. The purpose of garden is to house such artwork.

	
Figure 2.90: Tall, slim lighting columns, a striking walkway and colorful flowers enliven the walk from the restaurants to Mission Street at the northern end of the great lawn. (Osmundson, 1999, p.74)	Figure 2.91: Mini Roof Top, New York, USA. (Lawis, 2008, p.27)

2.6.8. Water Features

The use of water on roofs is restricted only by weight and strong winds. It is possible to have reflection pools, waterfalls, streams, fountains, sculpture and moving water in unlimited design configurations. If water features are planned well in advance of a building's construction, the landscape architect can compute the weight requirements and work with the building's structural engineer to ensure the roof can support the water feature. The water supply can be designed and installed easily in the ceiling of the floor below. Creating a body of water on a roof presents special waterproofing concerns, for leaks onto the roof must be prevented. The edge of a large body of water such as a reflecting pool can be built in a number of ways using formed concrete curb walls (Baker, 1980).

If an elaborate water feature is desired on a relatively low strength roof, a relatively low strength roof, a combination of shallow water and precast artificial rocks is a possibility (see figure 2.92). Lightweight concrete and fiberglass can be poured into plastic forms molded from natural rocks is a possibility (see figure 2.93). A whole new world of water and rock effects is thus possible in green roofs. Although some may object to the use of artificial elements in the landscape, it should be noted that vegetated surfaces on roofs have many artificial elements, such as soils, light, and irrigation. Even their location is artificial to produce a garden on a roof, one must occasionally rely on artifice to achieve a natural appearance not a blanket endorsement of using artificial elements everywhere; the practice of replacing real plants. In some cases, however, practical considerations prevent the achievement of a spectacular effect if only natural materials are to be used. The combination of rock and water may be such an effect; their inclusion in a green roof should not be rejected out of hand (Jellicoe, 1975).

Figure 2.92: A water flows over a series of brick steps. The street is at the top; the plaza at the right. Shinjuku Mitsu Building, Tokyo, Japan.
(Arroyo, 2012, p.132)

Figure 2.93: A smaller supplemental fountain wells up in a recessed brick pool. (Arroyo, 2012, p.132)

2.6.9. Windscreens, Shelters and Other Structures

It may seem that including a built structure in a green roof is in conflict with the whole concept of greening roofs. But in intensive green roof, that is, those that designed gardens at ground level certain structures are as appropriate on the roof as they would be in a local park. For example, some structures are functional in moderating the effects of climate and weather. A small shelter can serve as a widescreen as well as a place for people to congregate during a cloud brust. Sheltered structures can also alleviate the effects of heat and glare.

As design accents, they provide visual interest. A seating area, for example, is more memorable when it is shaded by a covered pergolas. Small structures are especially effective at the terminal point of a path or as the focal point of view. Such features can take on even more meaning when they are planned as the central element around which to rest of the garden is designed. They become the focus of the garden visually and the center of the garden's activities literally. Figures 2.94 and 2.95 are but a small indication of how these structures can add interest and variety to a garden space.

	
Figure 2.94: Ark Hills Center, Tokyo Japan. (Nishita and Carter ASLA, San Francisco, 1999, p.45)	Figure 2.95: Ark Hills Center, Tokyo Japan (Nishita and Carter ASLA, San Francisco, 1999, p.45)

2.7. Summary of the Chapter

Green roofs give a sense of isolation from the urban environment. They can also promote community within a city. Residential gardens on top of apartment buildings bring together neighbors whose only other contact might be a brief nod in an elevator. Green roofs associated with office buildings provide a place for employees to mingle in a more relaxed setting. Public green roofs serve a myriad of community functions, as a space to meet, to socialize, to attend special events. In the suburbs, ground level parks, plazas, gardens could fill such needs, but in built-up cities, roofs are often the only space available.

Roof gardens can also enable city dwellers to maintain a connection with nature that might not otherwise be possible. Over the last thirty years, efforts have been made to insert nature into the urban landscape by placing potted plants on sidewalks, planting street trees and landscaping spaces and median strips of streets. Aims that include greening the environment, creating a sense of community, increasing access to fresh produce and designing in an environmentally responsible way are seen correctly as mutually inclusive.

In this research, green roofs have been handled in Chapter 2. Examining theoretical framework of green roofs continued with deriving a methodology for their design elements, including the role of green roof, space strategy for green roof, landscape form, history of landscape and green roof then follow up green roofs for different building types and their design elements. This information will create a base for the case study in Chapter 3.

Chapter 3

DESIGN OF GREEN ROOFS IN RESIDENTIAL BUILDINGS

In this chapter, selected residential buildings are reviewed according to housing typology and their design elements. This chapter is divided into two sections. In the first section 3.1, the analysis method is given and in the section 3.2 the green roof strategy at residential buildings is evaluated.

3.1. Method of Analysis

The pragmatic considerations of green roof in housing and its spatial dispositions have been chosen in line with the theoretical review. The selected residential buildings are:

1- Justus Van Effen Complex- The Green Street in the Air (Rotterdam-The Netherlands)

2- Hillside Terrace-The Slow City (Tokyo-Japan)

3- Jeanne Hachette Complex-My Terrace-In Front of My House (Paris-France)

4- Residence Du Point Du Jour-Cristal Liquide (Paris-France)

5- Barbican Complex-An Exquiste Ghetto (London-United Kingdom)

The design of green roofs in residential buildings is viewed as a suit tailored to the subjective desires of the architects, is a relatively recent phenomenon in the green roof design approach. The ‘vegetated surface’ or ‘green surface’ seen as the subconscious requirements in residential buildings has become the environmental profile of the resident’s individuality. This concept is supported by the state subsidy green urbanism strategy which flourished to increase the construction of green roofs in residential buildings. It makes the link between property and individuality of space as universal. It is no longer a privilege to build a green roof according to one’s own desires, dreams and ideas but rather integrates social order which appeals to the concept of design elements of green roofs.

Residential buildings have to be considered from the perspective of the specific green roof implementations, since a residential building has a significantly longer lifecycle than its first resident. The concept of typology playes a crucial role in the development of the critical and scholarly objectivity with which green roof design elements re-established or re-organized the autonomy of residential buildings. The design elements of green roof and typology are in a position to react selectively to improve the quality of life and the challenges of its specific environment –either by means of approaches of green roof design such as green terrace, balcony, loggia or elevated green street. At most these principles offer one possibility among others to reconfigure space. It is interesting to note that typology is intended to address central problems of multistory residential buildings while applying the green roof design elements because it shows differences between context and implementation. For that reason, the concept of type is defined only vaguely here.

After understanding the theoretical framework of green roof and its design elements as discussed in chapters 1 and 2, fifty of contemporary residential buildings were examined and their particular qualities studied and categorized before choosing five buildings selected to examine and to evaluate in more detail according to their theoretical framework. Four aspects served as leitmotifs in that process:

- Definition of the Residential Complex
- Building Typology
- Design Elements
- Evaluation of Green Roof Design Approaches

In the first category, the research includes the understanding of the main architectural value of the building within it's the main purposes of design and contextual considerations. Another essential part is the examination of the building typology to understand how architects apply green roof designs to their projects. The objective of this part is to demonstrate the distinct modes of outdoor spaces as embodied in loggias, roof terraces and balconies (see figure 3.1).

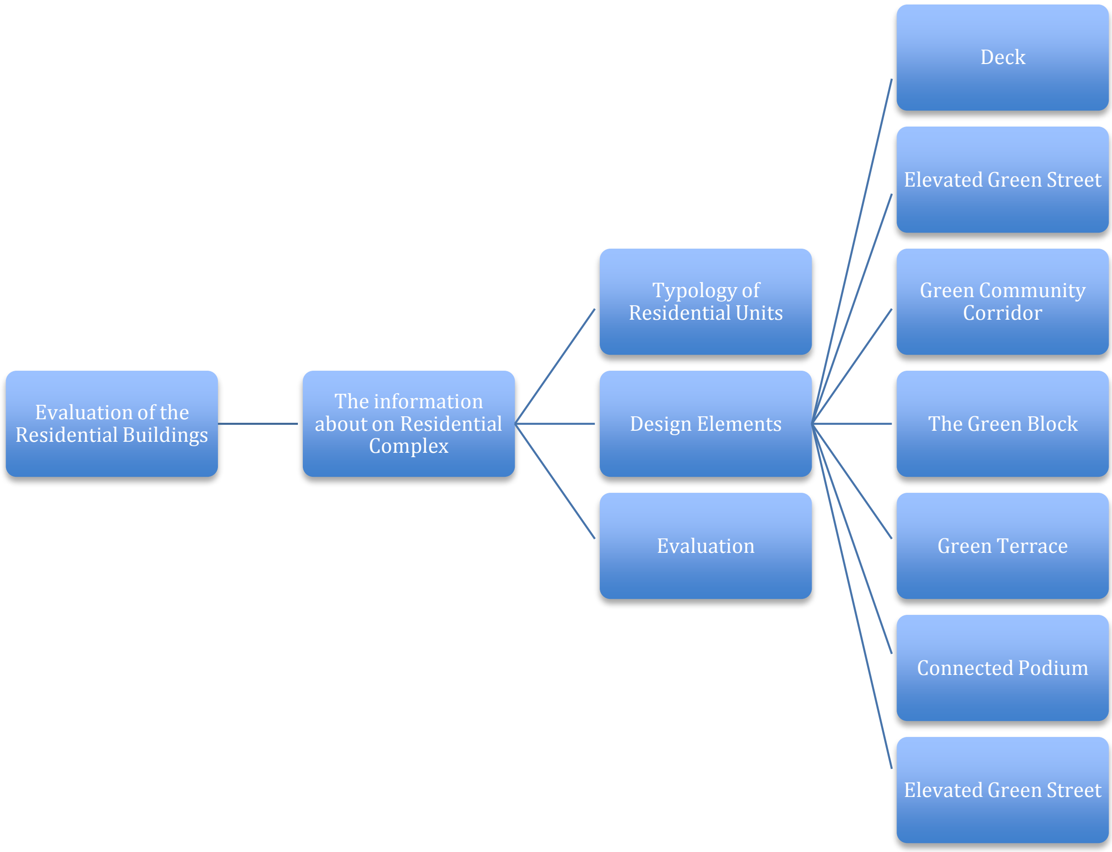


Figure 3.1: The methodology of evaluation of the green roof approaches in residential buildings.

The research deliberately focuses on the approaches of green roof designs, which are assigned to the environment. The third factor in typological study is the green roof design elements. The research aims to show that they have been subject to a definitive presence in design of green roofs in residential buildings. On the one hand, the diversity of building typology and design elements made changes to the characteristics of space; on the other, they are used quite differently as a result of social change. The fourth and final category is the evaluation and highlighting the main part of green design elements, which changes on green roof approach interface.

A green roof design in residential buildings 'speaks' to its surroundings through its design elements and character; green roofs become green linkage of the city which shapes it at the same time. The case examples chosen for this study are intended to explore in particular the possibilities that contemporary green design elements and techniques offer to formulate the green design concept.

These residential buildings are examined according to the theoretical and descriptive research has already discussed above. The main aim of this research to understand the design elements of green roofs in terms of planting variety, containers, paving surfaces, furnishings, lighting, shelters, sculpture and water. This residential units will be examined as a case studies to evaluate these headings then highlight the main points of design elements to implement green roof design requirements.

For the theoretical analysis, inventory forms were prepared. Each residential block was analyzed using inventory forms (Appendix B, Table 1 to 5). Pictures, site plans and plans of sections of the buildings were also collected for the research. The green roofs of the residential buildings are reviewed according to typology of each building and how it effects the green roof design. The research also seeks to evaluate the design elements of residential buildings whilst also evaluating the design elements for each residential building. The main findings of the research shows that housing typology and green roof design elements create a variety of green roof concepts. These concepts include the green roof design elements. However, their effects on spatial organization, architectural and social value is different from each other. For this reason, the five successful case studies were chosen. The selected residential blocks are evaluated separately for their green roof designs (balcony, terrace, loggia, deck, elevated path, podium and rooftop) elements in detail. The selected residential buildings were evaluated utilizing the inventory form in (Appendix C, Table 1 to 5).

3.2. Evaluation of the Residential Buildings

3.2.1. Justus Van Effen Complex- The Green Street in the Air

The Justus van Effen complex comprises two blocks, which meet a central unit where the shared services are located. Initially it contained 264 housing units and 17 different types (see figure 3.2 and 3.3). In the courtyard there is a building, which is one storey higher than rest of the complex (Goede, 2009).

Figure 3.2: Courtyard view.
(Crosby, 2001, p.13)

Figure 3.3: The main entrance and front deck of common areas.
(Crosby, 2001, p.13)

The design consideration arrived at a symbiosis between the terraced housing typology and the closed block with interior communal courtyard typology, between the individual and the collective. Aiming for this new concept to take on the appropriate scale, the design requirements offer to locate the two blocks into one and pierced the perimeter creating access points for residents, this way transforming the interior into a semi-public green terrace.

This green space is equipped the block with private and collective gardens, as well as a common service building, which is located at the centre. Lastly, indoor and outdoor spaces are incorporated different access solutions, which changed according to the location of the dwelling in terms of responding sun and wind direction. With this solution this design consider to reaffirm the green street as an element, which linked not only the elements built into the section but also the collective living units and the residents of the housing complex. Green spaces value the sense of community yet was unwilling to discard individualist features such as subtle degrees between the indoor and outdoor green vegetated community gardens. The protection of the privacy, which had been relinquished in the alcove-houses yet at the same time encouraged communal living (see figure 3.4 and 3.5).

	
Figure 3.4: Elevated Street provides access to the residential units. (Crosby, 2001, p.43)	Figure 3.5: Elevated street provides social area for residents. (Crosby, 2001, p.43)

As an alternative to this approach, the residential complex proposed the monumental block and in this context, designers stands out as an even more advanced proposal;

green terraces and urban squares widen the block and add internal branching to the perimeter block, enabling access to the residents to pass through lengthways and crossways within located on green edge containers, hence facilitating neighbourhood transit. This way provides to transform the interior courtyard into a semi-public space.

The designer's objective was to recover the direct link between street and dwelling, which had disappeared from the social housing blocks of the time. In this complex, designer manages to give all the dwellings direct access from the green spaces from the outside, either from the elevated street of the second floor deck. Additionally, the shade from the ground floor entrance elements, the first floor balconies, the deck halfway up the façade and the unframed openings on the third floor all give each design components an individual dynamism yet less these sections blend seamlessly into the estate as a whole, despite the great complexity of the points at which the different layouts come together (see figure 3.6).

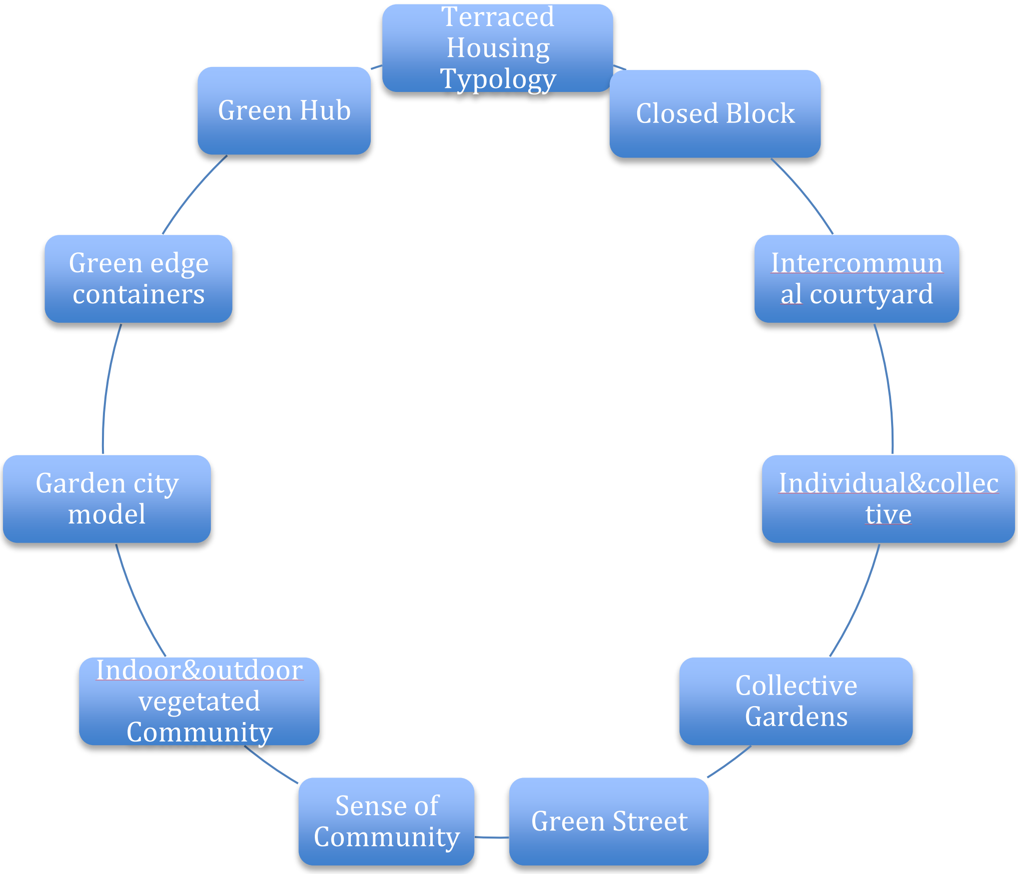


Figure 3.6: The evaluation of the residential complex.

This complex introduces picturesque features from the garden city, indeed even from the surrounded environment, into the courtyard, helped along by the vegetable gardens, which neighbours on the ground floors were allowed.

Typology of residential units

This project was based on superimposing three different types of housing with three different types of green street access; ground floor dwellings, first floor dwellings and penthouse apartments on the second and third floors. While the ground and first floor dwellings have a width of supporting green walls, the penthouse apartments on the second and third floors only have a width of green vegetated spaces (see figure 3.7).

Figure 3.7: The diagram of examining housing typology in green roofs.

Access to the ground units is from the courtyard access to the first floor units from a private staircase. Great care was taken to protect the entrance to both dwellings by using a container, which planted green shrubs or flowers to support the balcony. Each housing type has its own access type and the exterior street is designed to give access both to the row houses on the lower floors and to the penthouse apartments. Originally, the ground floor and first floor dwelling entrances had a private front garden with a private hedge. Today, the entire interior courtyard is a communal space (see figure 3.8 and 3.9).

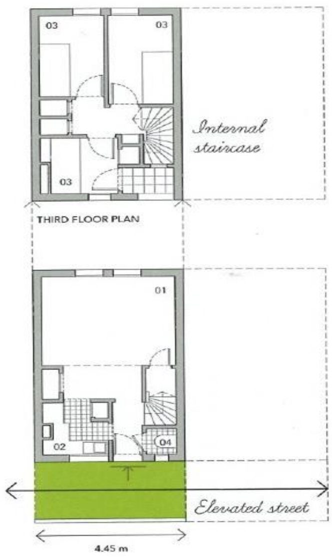
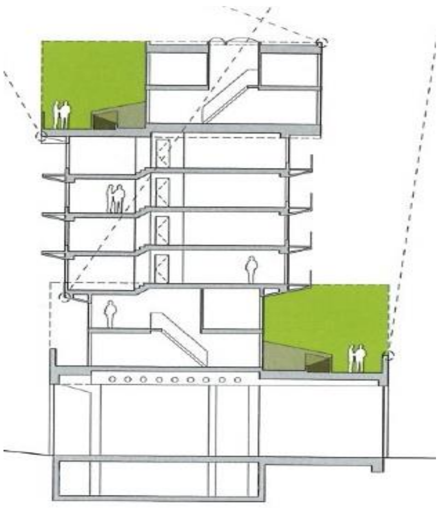
	

Figure 3.8: Penthouse Plan (Emstede, 2011, p.49)	Figure 3.9: Section of the residential building which demonstrates the green elevated streets and residential units. (Emstede, 2011, p.59)

Design Elements

- The native plantings on the roof have become established, so that the top of the elevated street for the building below is penetrated by horizontal vegetated deck.

- The interstate passes above and beyond the building. On the upper level, the overlook is backed by the densely planted roof, which conceals the excavation into the slope and helps to camouflage mechanical equipment parts of the building. Its roof has been landscaped with native flowering plants, a technique that successfully incorporates the building into its natural surroundings (French, 2008).

- It is interesting to note that smaller flowering plants and shrubs in concrete containers, ample fire-staircases with plenty of seating and cozy protected nooks that give people a place to relax out of the mainstream, all invite people to use this space as more than just a means to get here to there.

- Seating consists of integral benches permanently attached to the broad tops of the raised planters. Although ideally suited for flexible seating arrangements, no comfortable movable furniture has been provided.

- Furthermore, durable concrete is used for paving, plant containers and seating throughout, with hardy and wind resistant trees, shrubs and ground covers chosen for minimal maintenance.

- The materials for the garden were raised up to the solid concrete slab on top the roof bit by bit from the ground below to form a detached piece of landscape, independent of the ground, with its own irrigation system.

- All paving and structures are made of lightweight concrete and all rocks or boulders are lightweight pumice stone (Sitta, 1983).

- Additionally, the entrance to the roof garden is at deck level flanked by potted plants. Furthermore, next to the plaza is a small garden of perennials, low shrubs and ground cover, which provides a pleasing contrast to the open space.

- Redwood trees have been planted in the background to shield the square from glare produced by the highly reflective wall of a neighboring building, and tall-growing trees have been planted along the square to provide more shade in the future.

Evaluation

Deck

In the recent research mentions that of the time can see children playing on the deck or people enjoying the peace and tranquility of the shared interior courtyard. The deck is between 2.3 and 3.3 meters wide (Ebner, 2009). The built solution is not so much a theoretical pragmatic solution. The preliminary design consideration is the inspiration from interpreting the virtues of social education, instilled in the individual. This learning process results from citizens meeting and socializing in their everyday relations, building up certain neighbourhood bonds generated by this utopian brotherhood.

The main criticism of the deck was that it shaded the dwellings on the floors below. Banham (1974) mentioned that while the deck never offers grandiose perspectives, but keeps down to a domestic scale of views along its length, the act of walking along one is a serial scenic experience punctuated by irregular spatial constrictions, that is continuously fascinating (see figure 3.10).

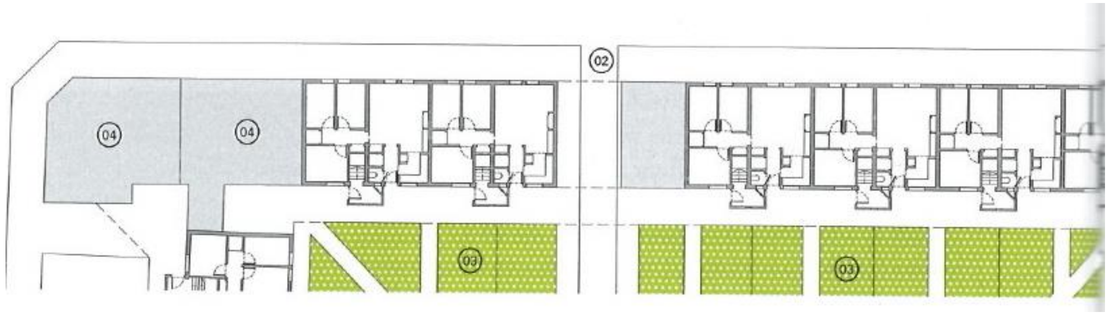


Figure 3.10: First Floor Plan (Emstede, 2011, p.39)

Elevated Green Street

The main novelty in this housing complex is the elevated street, which was to be mechanically repeated in social housing. This was the first time the resource was used in Europe. The proposed concept of the elevated green street to combine the density of the monumental block and the exterior-interior relationship of rows of housing (see figure 3.11 and 3.12).

The main aim is to transfer the freedom and spontaneity of the vegetated street to the elevated street making the deck an ambiguous element. The green street in the air is a non-stop one kilometer walk, full of twists and turns, different widths, in which a series of small events-volumes, opening looking outwards, street views, encounters with the stairwell, continually altering the perception of the setting.

The main influence is clear as far as the access deck is concerned, yet not in the general approach to the project. The design maintains the close relationship with the local environment and between residents.

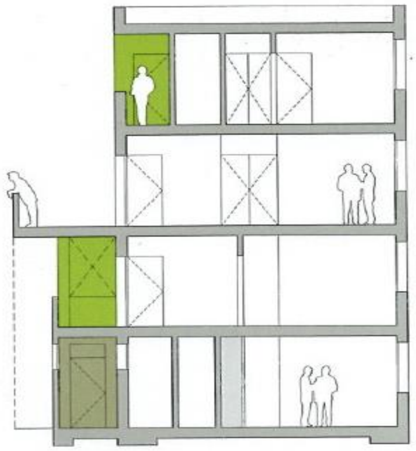


Figure 3.11: Section of the building which demonstrates the deck. (Emstede, 2011, p.49)	Figure 3.12: Section of the building which demonstrates the deck. (Emstede, 2011, p.59)

3.2.2. Hillside Terrace-The Slow City

Hillside Terrace is a miniature city, built in phases, which took over thirty years to complete and is home to low-rise buildings, interconnected public spaces, low green walls, thresholds, passageways and vegetation (Koolhaas, 2011).

The main aim is to build a continuous urban landscape by using a combination of staggered volumes, which move forward and backward in relation to the street. The ground floors are in some cases transparent or are set back and lend continuity of landscape to spatial elements such as corner containers for vegetation in the aim to create a small city atmosphere within a megalopolis (see figure 3.13 and 3.14).

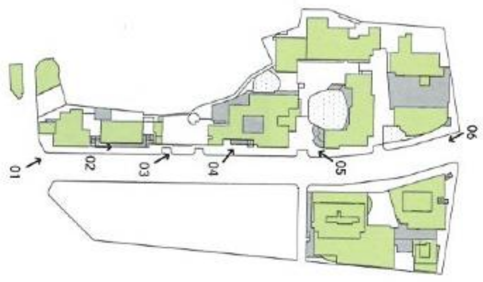
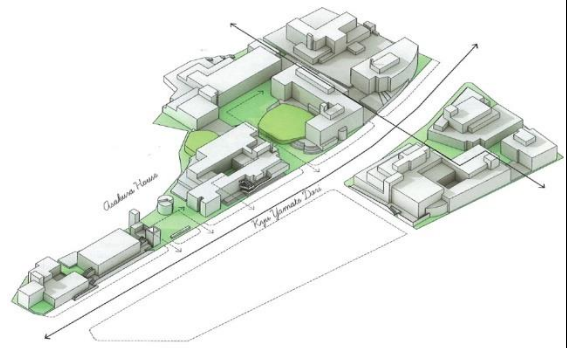
	

Figure 3.13: Site Plan. (Mozas, 2011, p.334)	Figure 3.14: Isometric View of Site Plan. (Mozas, 2011,p.339)

The priority for green urban design, according to this building purpose, is to recognize nature. This attempt is often lost due to the difficulty managing an overly ambitious green roof design programme, in the aim for its implementation to create controlled environment. In Hillside Terrace, the vegetated space applies a certain sense of depth to building’s physical character, modulated by a sequential space between activity and privacy, between public and private, between the street and the interior. The depth of vegetated space is based on the layout of the transparent entrance halls, which allow for interconnections between them and give the impression that there exists an inbuilt spaciousness to the project, which extends out throughout the location.

The space allows for different loops in the paths. The views towards the green spaces are as significant for an interesting route as the completely transparent views through the ground floors of the buildings. The importance of green space in this complex is evident as it based on three premises; green space has to allow people to enjoy their solitude, green space will be enhanced by the more layers and more meanings integrated and common space has to become a catalyst for human interaction (see figure 3.15 and 3.16).

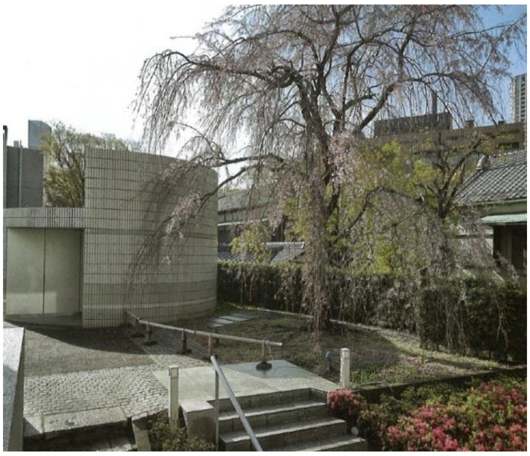


Figure 3.15: Green Roof View. (Mozas, 2011,p.342)	Figure 3.16: Green Community Corridor View. (Mozas, 2011, p.371)

The main concern has focused on the green roof design strategy and its design elements rather than the plan. The green roof policy is more involved in the green corridor principle of time than the plan, which targets that ideal green urban design. The fact that these green design considerations are allowed to examine two things: the slow rhythm identified with the life cycle of the buildings and the inexorable hand of fate which replaces common areas with vegetated roofs (see figure 3.17).

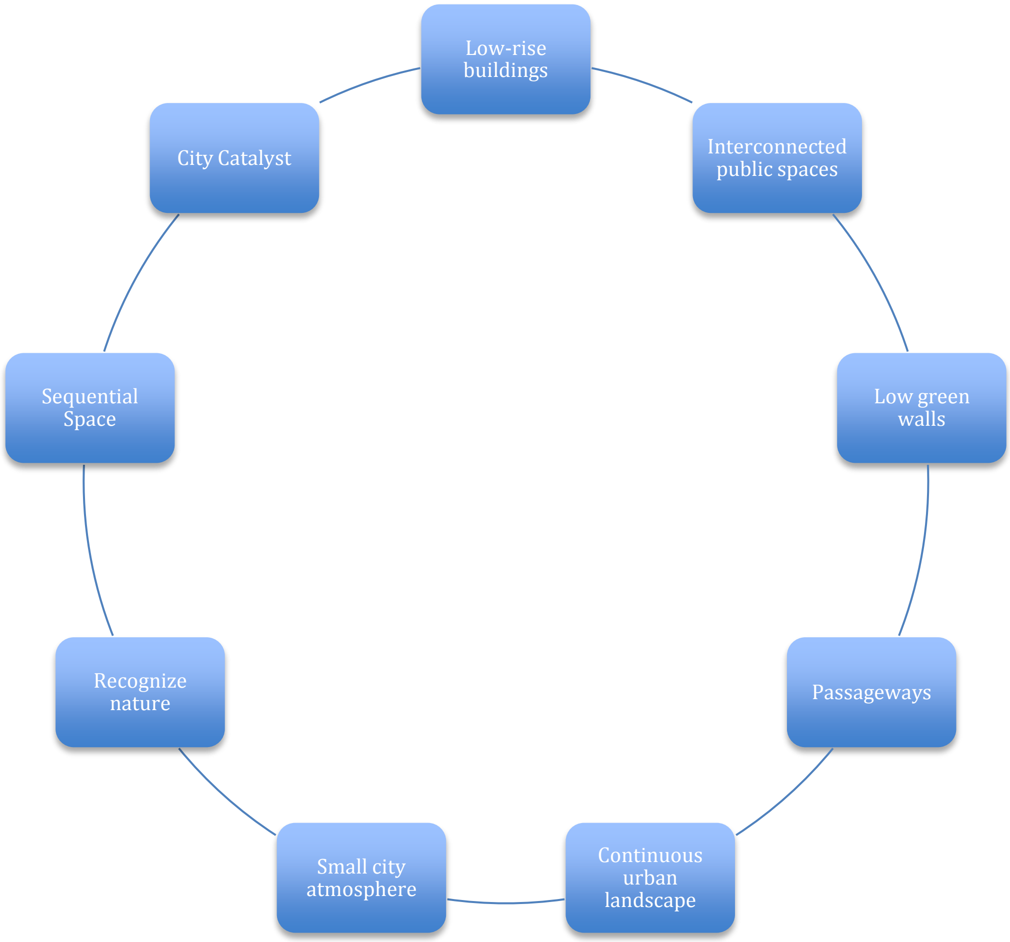


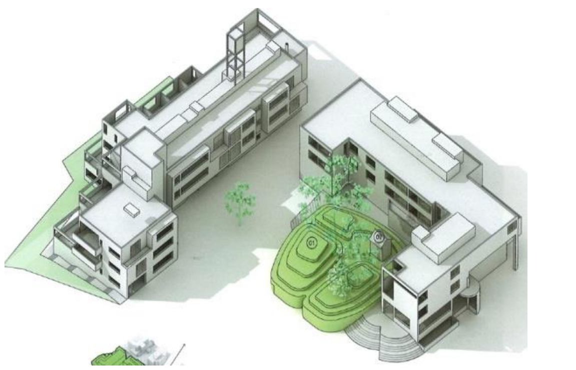
Figure 3.17: The evaluation of the residential complex.

This project defines the concept landscape of time as the deliberate aim to create continuous sequences free of folds in space and time by taking advantage of the options offered by the natural features and reinforcing them with subtle changes in the architectural phase of green roof design.

Typology of Residential Units

As the construction of Hillside Terrace progresses, a synthesis between green roof systems and its design elements begins to emerge. In this phase, a large underground space is built below a void known as 'Hillside green rooftop'. It is set aside residential use for citizens.

The design strategy positions the programme underground so as not to upset the existing balance. Access from the vegetated area is provided through a concrete cylinder, which rises up from floor level on the street. It includes a first mezzanine type floor, which does not occupy the whole floor plan and provides access to the main space (see figure 3.18, 3.19 and 3.20).



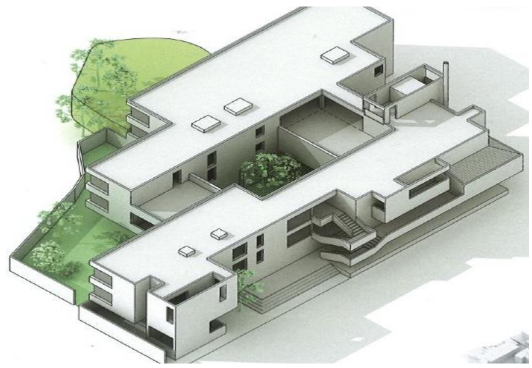


Figure 3.18 and 3.19: Isometric View of Residential Blocks. (Mozas, 2011, .349)

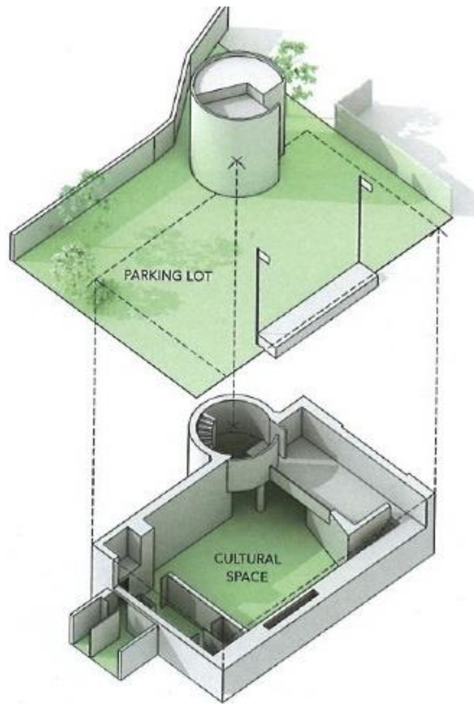


Figure 3.20: Isometric View of Typical Residential Unit. (Mozas, 2011, p.343)

A ground floor passageway crosses the street providing access to a vegetated courtyard with a large tree standing in a prominent position. In a more set back location is the residence, with a floor plan, which embraces the stepped garden and hence serves to green frame the perspective. At the same time, green strategy strives to preserve the initial idea of clearly defined volumes enclosed by vegetation. The original landscape of this district had been altered and when construction commenced there were no trees left. Nevertheless all the paths and spaces within the plot have been replanted with large tree species in order to produce integration between architecture and vegetation (see figure 3.21).

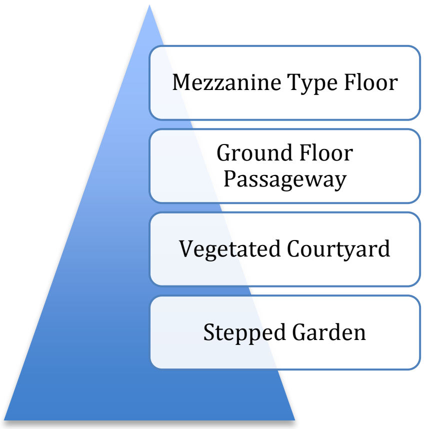


Figure 3.21: The diagram of examining housing typology in green roofs.

Design Elements

- The main plaza is surrounded three sides by high white precast concrete walls that are relieved by a horizontal stripe near the top; these walls, along with rows of pin oak trees at street level, screen the vegetated space from urban noise outside the space.

- The plazas at each end of the long, narrow site feature a formal grid of raised planters of granite and white precast concrete planted with mature trees and seasonal flowers.

- Planters along the perimeter walls contain perennials, ornamental grasses and climbing vines.

- Low light fixtures attached to the planters reinforce the grid pattern used in the space. It is interesting to note that lighting bubbles also attached to the raised beds and other concrete element are decorative by day and provide a low level of light by night.

- Furthermore, shade trees are planted in relatively small rectangular openings surrounded by concrete curbs. About half of its surface is paved with compacted decomposed granite, broken stone that has a high content of fines. After it wetted and rolled, this material forms a hard, smooth walking surface that is easy to maintain and repair. Its color and textured look provide a far more pleasing appearance that concrete does.

- A huge concrete shade structure offers protection from the sun; its great height and depth are in keeping with the scale of the plaza and surrounding buildings. Perhaps most notably, lightweight plastic-covered metal furniture is provided throughout the space during the spring, summer and fall. Although some outdoor furniture is provided, more would improve the scale and diminish the impression of emptiness conveyed by the bare expenses of concrete paving.

- The addition of potted perennials and colorful annuals are used to the simple ivy, shrubs and trees now in place would also improve the scale and brighten the space. Plant materials include Chinese pistachios, Japanese maples, golden rain trees, flowering cherries, oleanders, camellias and ferns. Over time, wisteria has completely covered a trellis (Hicks, 1965). A panel of lawn between two square areas is both decorative and provides a place to sunbathe.

- The main design principle of this green roof, as one exits between the motorway and pedestrian walkway, is an intimate plaza with a central sculptural sundial in a round planter, backed by an ornamental trellis on the parapet. The heavily used roof garden has a formal layout, with a central axial plan bordered by large pots containing specimen crab apple trees (Howard, 2012).

- Flanking the central area on each side are rectangular sitting areas, providing ample comfortable seating; individual benches provide additional seating. Throughout the space, rectangular concrete containers are filled with flowers for seasonal color.

- The very striking paving is of concrete outlined by bright light colored tile. Its pattern has been correlated to the location of every major element in the garden and is integral to the garden's overall design (Kahn, 1992).

Evaluation

Green Community Corridor

This project target has always been fascinated by concepts regarding intermediate spaces, such as the green community corridors. It is a very common green roof policy in Europe and this exterior part of the house is conferred a social function where neighbours can chat and children can play (see figure 3.22 and 3.23).

The green roof strategy tends to have several steps going up to the main floor of the dwelling, which increases the privacy of the interior in relation to the ground floor. The spatial organization seeks continuity in this whole series of spaces, going from the street, the row of trees, the dwelling and the back gardens. These corridors mediate between the street and the dwelling and which make the transition feel less evident. This is a device to obtain a transition space between the integrity of the street and the quieter residential areas.

This green community corridor concept is formed by series of parking areas, small neighbourhood stores, entrances and playgrounds. It is an environmental wall, which adapts itself to activities inside and outside the community. This theoretical concept is put into practice in Hillside Terrace in a subtle way by creating a protective barrier containing specific uses for residents. Hillside Terrace is an amalgamation of nature elements with a shifting ambiguity, which draws indiscriminate attention from the whole part and form the part to the whole, which preserves great conceptual green openness with multiple interconnections. This fragment residential complex can only be understood as a symbiotic relationship between the architecture and nature.

	
Figure 3.22: Planted street within brick paving on the floor. (Mozas, 2011, p.363)	Figure 3.23: Planted Courtyard, which provides social activities for residents. (Mozas, 2011, p.359)

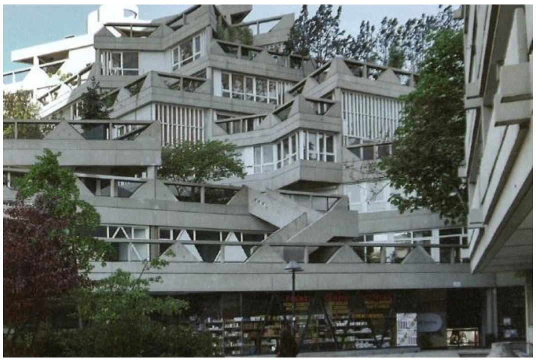
3.2.3. Jeanne Hachette Complex-My Terrace-In Front of My House

When it comes to cultural practices of everyday life, such as housing, it is not possible to regard green roof aesthetics without taking into account the perspective of their use. In contrast to design, it has a a physical situation of being attached to a specific place and identity. Due to the fact that available land for real estate development has become limited in cities, and therefore excessively high in cost, many people have left cities to find new homes in the suburbs. However, once outside the city, people often realize they have moved to places that are too isolated to attract and sustain the quality of life they expect, and often, the suburbs are unsafe.

According to Bohigas (2009), it is important to preserve and develop a traditional understanding of the city. Bohigas (2009) also characterizes as the standard bearer of urban design a type of development that gives collective space the leading role and, consequently any action of redeveloping an existing city or building new neighborhoods must start from the reconsideration of collective space, the form of which is determined by various factors but in particular by the transformations of the context.

Houses that have existed for a long period of time necessarily go through many transformations, with successive generations changing the ways they are occupied and used. Generally, what guarantees a building’s longevity is its dynamics and ability to change and the possibility for it to have more than one kind of use. Specifically in relation to housing, diverse exchange processes take place between a house and its users, for example, the residents enter into a relationship with the living space, possibly identify with it or change aspects of it and end the relationship at a later point in time. Simultaneously, some constants may remain over the course of time including the physical building elements and spatial structures. Residents leave traces of use in the houses they occupy and these traces can provide important information about the pre-requisites and conditions that underline the longevity of housing in general.

Rossi (2006) described residential buildings as constantly changing signs of everyday life and the expression of urban dynamics. However, Rossi (2006) also mentioned that residential buildings from the theoretical point of view, asserts that the greening strategies of residential areas contradicts a town’s dynamic development process (see figure 3.24 and 3.25).

	
Figure 3.24: Jean Hachette Complex, Paris,France. (Jacob, 1998, p.433)	Figure 3.25: Jean Hachette Complex, Paris,France. (Jacob, 1998, p.429)

This residential complex draws upon the urban concerns on the issue of diversity in social housing. With this hybrid building as a model, many urban planners fought against the division of functions and launched a manifesto in which they converted the city into a living organism whose parts were all closely related. According to this approach, building should grow formally and organically with vegetation as a necessary condition in the liveable environment. The planners also believed that the right to enjoy a unique dwelling was as important as the right to own a portion of natural space, not just a balcony but a real terrace where trees could grow. The outdoor space added privacy to the act of living there and made it possible to observe the actual dwelling from outside, from a typical view point, experiencing a sensation of near far yet far (see figure 3.26).

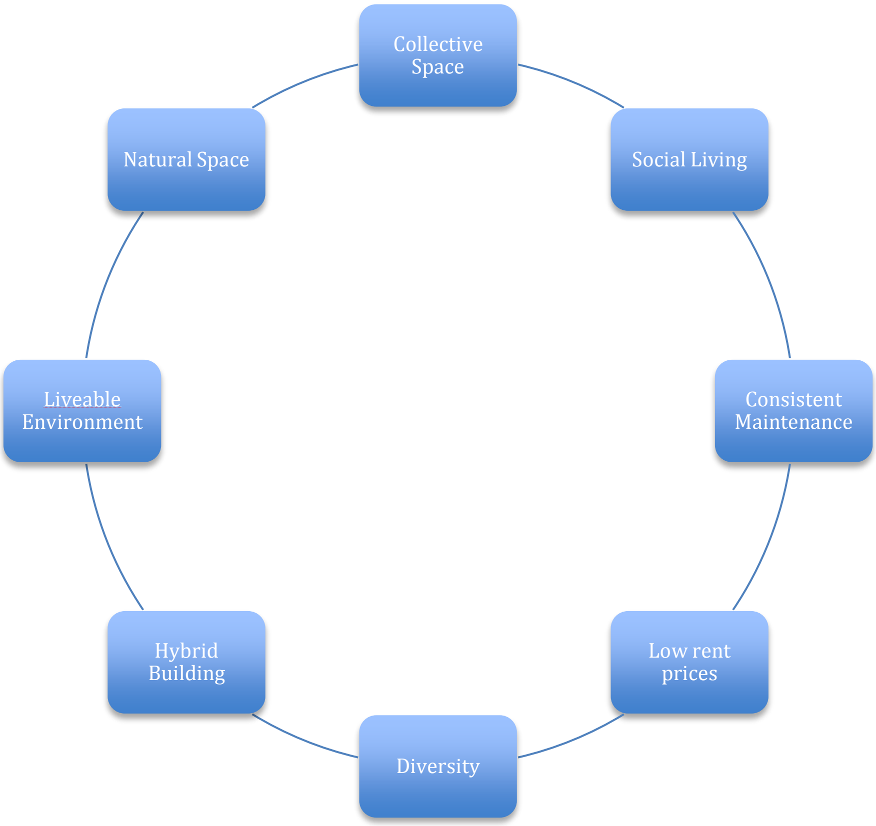
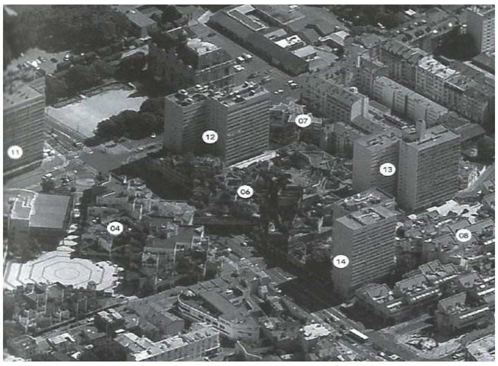


Figure 3.26: The evaluation of the residential complex.

Typology of Residential Units

The general floor plan of the complex is conceived as a continuous fabric which spreads out beyond the borders of the plot, invades public space and establishes relations with neighbouring organisms. It knows no physical limits and can establish bridges linking to buildings on the other side of the street or make specific contact with towers in the local environment (see figure 3.27). The segregation of functions (living, working, recreation and circulation) became discredited when the new schemes, due to their inherent doctrine, did not reach the complexity required for urban life to develop.

Planners believed that the city was a complex mechanism, which, in order for it to preserve its own structure, should periodically assume both the disappearance of some functions and the appearance of new ones. Planners also considered that urban life could not be activated unilaterally by urban planning unless an act of citizen appropriation also takes place. This meant that the existence of a complex structure made the design for each dwelling affect the relationships between adjoining units in terms of privacy and access (see figure 3.28).

	
Figure 3.27: Jean Hachette Complex, Paris,France. (Jacob, 1998, p.430)	Figure 3.28: Jean Hachette Complex, Paris,France. (Jacob, 1998, p.431)

The basic aim of imitating the complex organization of living meant that the structure and the spatial layout were incompatible unless a minimum process of dwelling standardization was to take place (see figure 3.29).

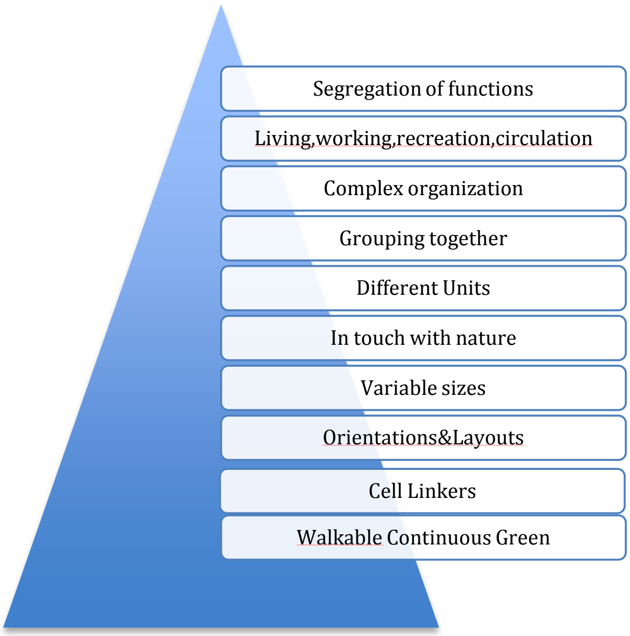


Figure 3.29: The diagram of examining housing typology in green roofs.

This social housing in collective buildings should be based on grouping together different units, each with its own identity and in touch with nature (see figure 3.30, 3.31 and 3.32). For this reason, in this case analyzing the concept of the typical apartment is impossible as the formalization of the complex leads to specific solutions, with no common features, unlike other more rational layouts based on repetition and the module.

In this residential complex, there are a wide range of dwellings of variable sizes, orientations and layouts. Each unit is unique and is built as just another element in an ensemble with complex relationships. The importance lies in understanding the building as if it were a living being in which the cell linkers are the key to the survival of the system.

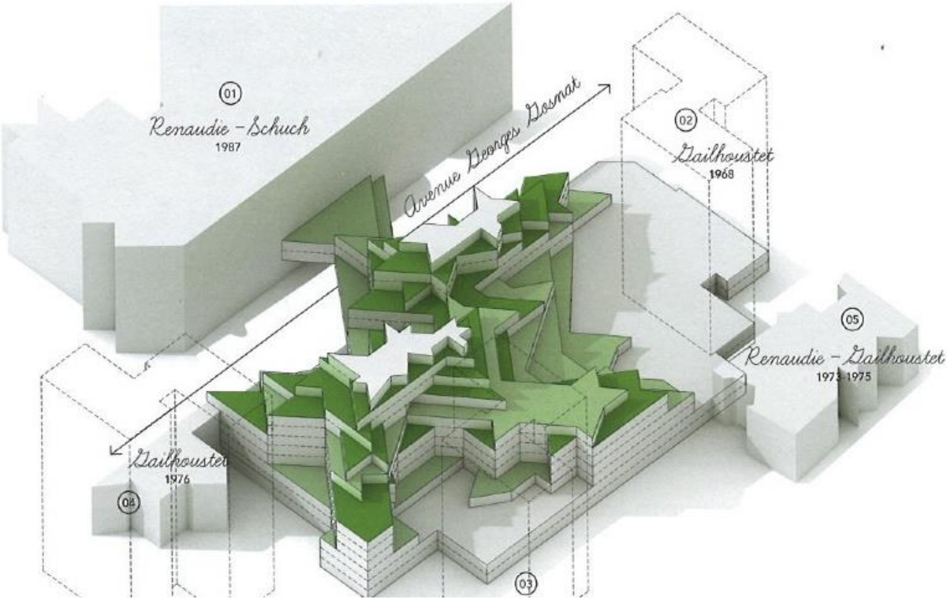


Figure 3.30: The spatial richness, which permits the walkable continuous green exterior is a world away from the narrow dark corridors of the complex. Designer tried to create a feeling freedom and of individual appropriation of space, something which does not appear in the one-way corridors of the conventional housing blocks. (Jacob, 1998, p.435)

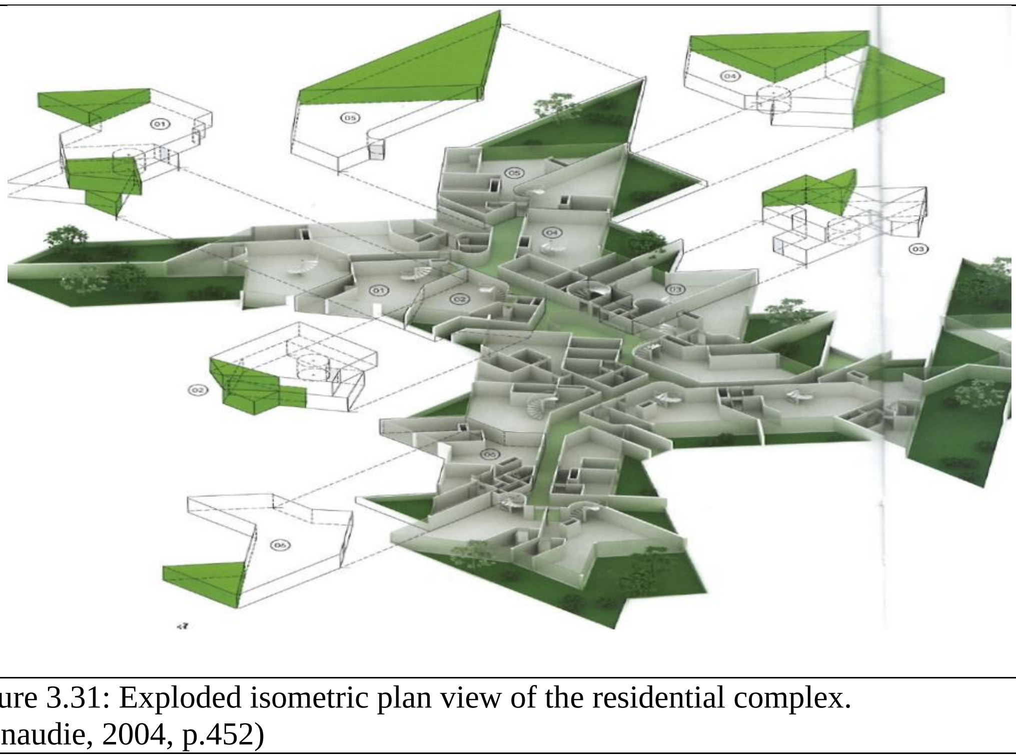


Figure 3.31: Exploded isometric plan view of the residential complex. (Renaudie, 2004, p.452)

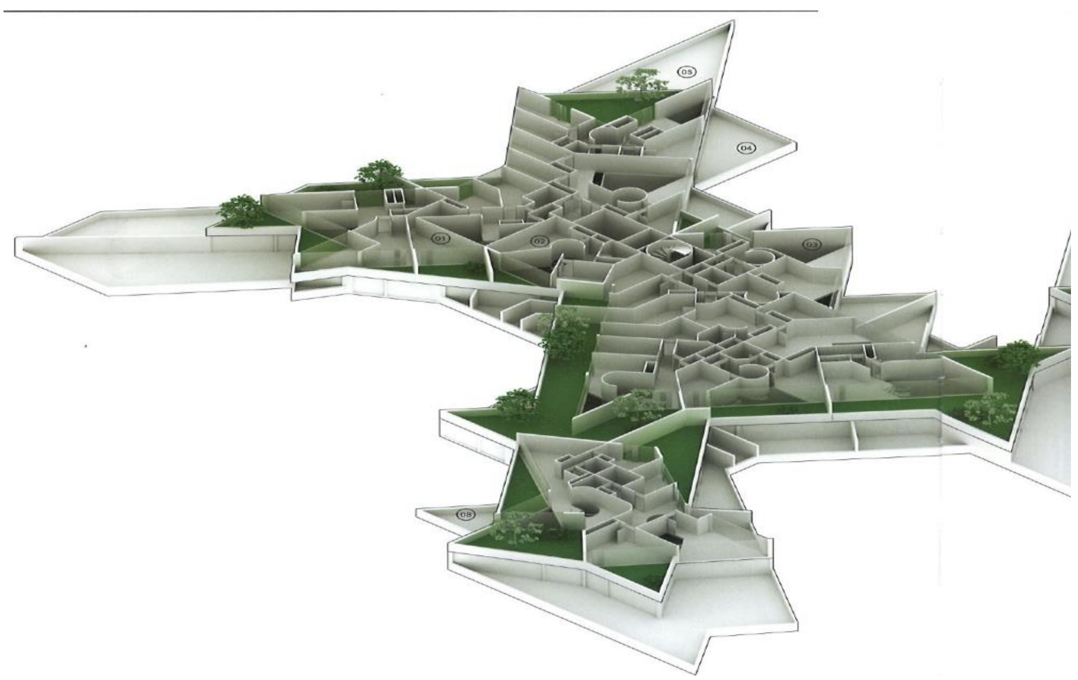


Figure 3.32: 3D spatial layout plan of the residential complex. (Renaudie, 2004, p.454)

Design Elements

- The entire paved area is finished in dark, tightly jointed paving bricks, which complement the plantings as well as the precast curbs and seat-high concrete edging bordering some of the greenery. Raked pea gravel is used along to the elevated walkway.

- Three clearly defined sitting areas, protected from breezes, are furnished with comfortable outdoor chairs; less formal seating is available on the precast-concrete edgers.

- Inconspicuous containers for edge planting are located throughout the space.

- According to the general layout of the plan, a reception room and a dining room are located at the opposite ends of the building. Each has access outside to a paved terrace, walkways from each end terrace lead to a smaller central terrace, which is slightly raised (Nicol, 2012). This smaller vegetated terrace can be entered from an interior hallway as well as from the 45 degree of triangular-formed terraces.

- The terraces are all paved in pure brut-concrete within grass. The stone and gross pattern of the end terrace near the elevated street is echoed in the tile-lined containers.

- The designed effect has been only partly realized with the new planting. As the small, multi-textured ground covers spread and the grasses grow in height, the continuity and contrast within the garden will increase.

- Stationary granite benches and raised planter boxes border the central terrace.

- Portable furniture is moved into the end terraces during warm weather. The principal plants throughout the space are rows of flowering crab apple trees, with evergreen ivy also used as a ground cover. Seasonal annuals planted in portable rectangular concrete plant tubs add color throughout the space.

- Lawns, shrubs and flowering trees cover the roof, camouflaging the building mass, so that, when approached from the building through the pedestrian walkway, the main activity piazza can barely be perceived. The design maintains the pedestrian walkway across the landscaped roof (Powers, 2010).

- It is interesting to note that the entrance side of the below-grade building is completely concealed by a grassy berm. Earth berms form a moatlike passage around the exposed end of the building.

- All trees have a fibrous root system and all have performed well in their new environment. All trees were left in the plank boxes in which they were delivered.

- The box formed part of the subsurface bracing, which eliminated the need for visible guying. Ultimately, the boxes and braces decomposed and the roots of each tree now provide its support (Lucan, 1982).

- Lighting is provided below eye level along all walks; in addition, separate mercury vapor lights are embedded in the soil to direct light upward into the branches of all specimen trees. The lights turn on automatically when the light level drops enough to activate a photoelectric cell (Packard, 1981).

Evaluation

Green Terrace

At first sight, this residential complex gives the impression that it merges with the surrounding urban block structure. The interlocking of neighborhood and building can also be analyzed as the residents of the surrounding neighborhood use the terrace of the housing estate as a green space, spending time there along with the residents. However, this is not always without conflicts, as semi-public space and public space are limited. The intrinsic perception of the housing estate focuses on the division of social space into parts, such as, the estate is not experienced as one integral unit, but rather as a perimeter block settlement with different entrances, or even as a row of streets (see figure 3.33 and 3.34).

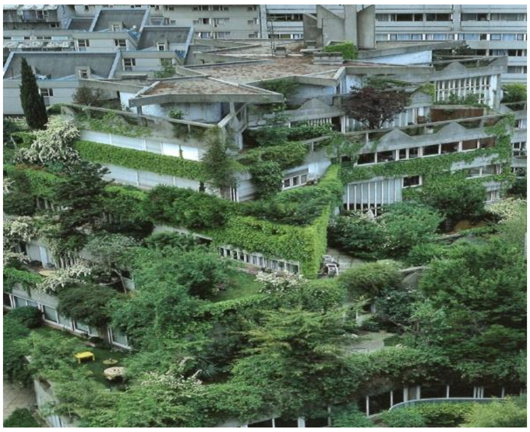


Figure 3.33: Vegetated Terrace and Green Wall. (Maurer, 2007, p.443)	Figure 3.34: Vegetated Terrace. (Maurer, 2007, p.456)

The Green Block

The perception of spatial structures in the Paris housing development and the surrounding areas is differentiated by axes, as seen in the rows of streets and by areas, as seen, in the public and the terraces. According to their proximity to these axes and areas, different qualities are perceived by the tenants living in different blocks (see figure 3.35). The central terraces form the housing estate's semi-private exterior spaces which are accessible to the local public since the entrance gates are not locked during the day. These terraces add to the high quality of life in the development and have the character of a green terraced mountain in the city.

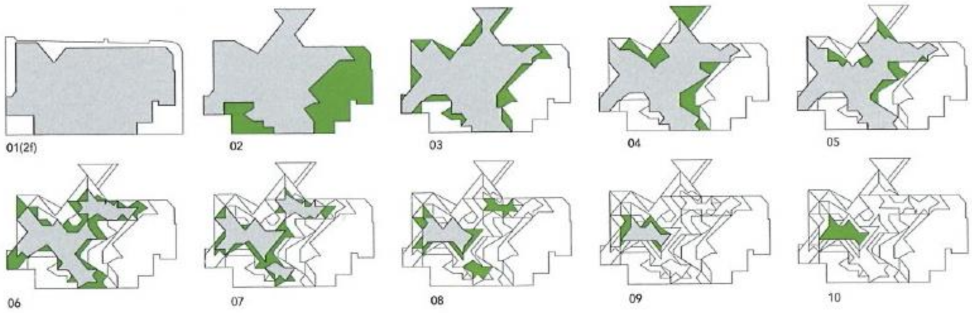


Figure 3.35: The plan schemes of the residential complex 0 to 9 levels.
(Renaudie, 2004, p.445)

3.2.4. The Residence of Du Point Du Jour-Cristal Liquide

Point du Jour is a private Housing development, with 2,260 dwellings, facilities and commercial units at affordable prices for citizens with an average income (Chapron, 2003). In this way, designers took some of the burden for public house-building off the region. This residential block location, the home ownership-based purchase agreement, the average citizen resident type, the quality of the build and the attention to detail in the open spaces of the blocks, have all led to the complex being maintained in terms of a green strategy and sustainability.

The urban conception of this complex is based on large open spaces, with lakes and vegetation, interconnected in several courtyards (see figure 3.36 and 3.37). Pouillon (2001) referred to this generic housing block surrounded by green roof constructions are delimited by four planes; firstly, the notion of space, this built space which has had such a great influence of nature. This is not a horizontal space but a space surrounded by edge planted containers which mark out a green terrace, this landscaped design element, from the residents perspective of view often called it, is in general delimited by four planes, at times by two case of the green street approach to design.

Pouillon (2001) also mentioned that the interior landscape of this urban complexes which one moves around a pedestrian level and which corresponds to a succession of atmospheres of different proportions, which opens outdoor and indoor activities in the perspective in a visualization of nature which shifts as the resident's moves around the green terraces.

<table>
<tr><td></td><td></td></tr>
<tr><td>Figure 3.36: Communal courtyard view with mature trees.
(a&t Research Group, 2013, p.287)</td><td>Figure 3.37: Communal courtyard view and podium terrace view.
(a&t Research Group, 2013, p.292)</td></tr>
</table>

According to this approach, this project optimized the structure, standardized the green roof strategies in terms of storm-rainwater collection, wind protection and waste-water recycling and reduced the interior circulation spaces in the blocks, broke the energy-efficiency requirements effectively into as many sub-contracted tasks such as vegetated terrace or roof, negotiated lower prices, cut profit margins and directly intervened in the accounting operations for the design elements of green roofs. All these factors are enormous innovations in the approach to combat within green energy strategies for a residential building (see figure 3.38).

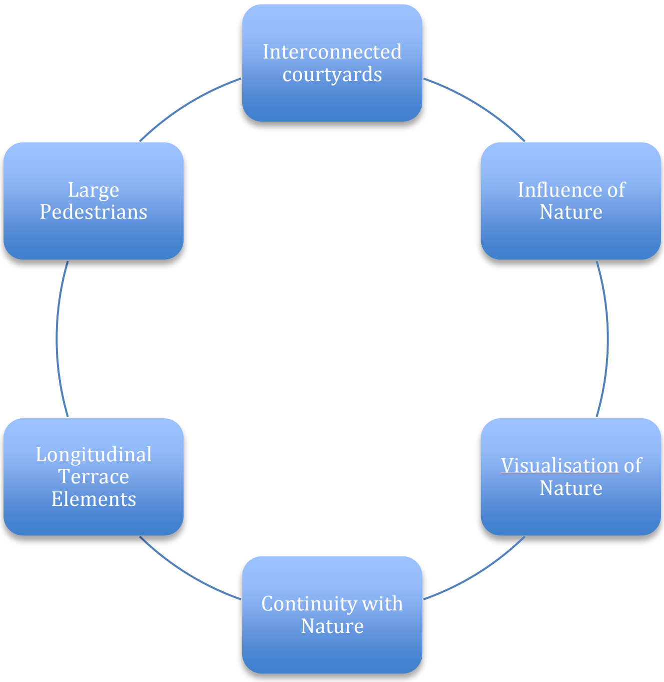


Figure 3.38: The evaluation of the residential complex.

Typology of Residential Units

Type 01 of the medium-rise blocks is a succession of two dwellings per storey for each access core (see figure 3.39). There are interior spiral staircases with wedge-shaped steps permitted under the legislation rules. The dwellings are front to back from north to south according to sun direction, with clear differentiation on the façade. However, terraces, balconies and loggias are given the main architectural element within their green roof design strategies (Durand, 1981). Type 02 is similar to Type 01 but with no lift, as these are dwellings in blocks with fewer storeys (see figure 3.40).

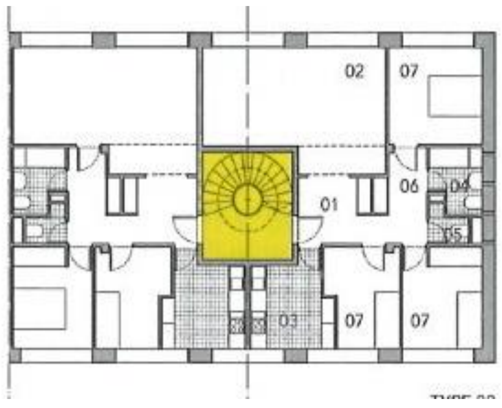
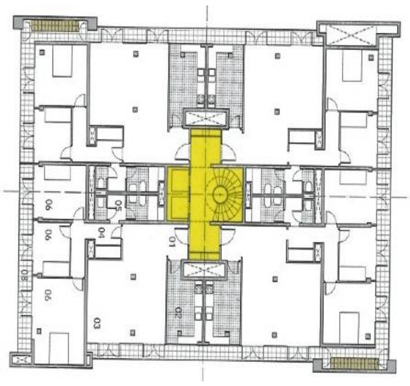
	

Figure 3.39: Type 01 Plan. (a&t Research Group, 2013, p.306)	Figure 3.40: Type 02 Plan. (a&t Research Group, 2013, p.306)

The layout for the towers contains four dwellings per storey, with the service cores grouped on the axes of the rectangle (see figure 3.41).

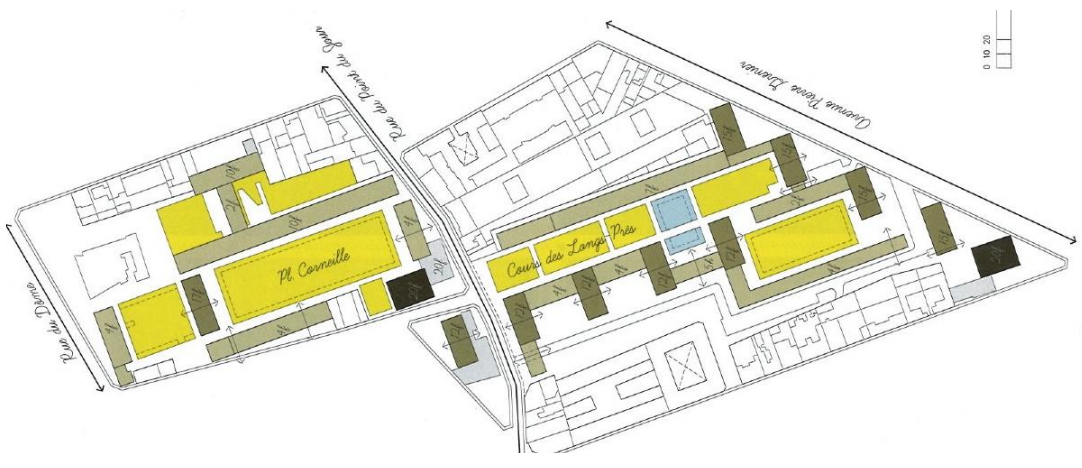


Figure 3.41: Site Plan. (a&t Research Group, 2013, p.306)

Circulation within the flats is through the living rooms. One of the main design consideration is that green terraces location because of sun direction limits the plant variety on the rooftop (see figure 3.42). With this in mind, the bedrooms are grouped together and separated from the living area by a hall, which provides horizontal vegetated corridor (Lucan, 2003).

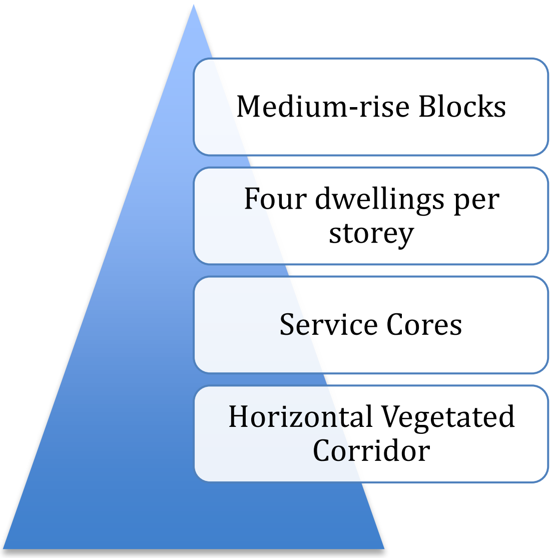


Figure 3.42: The diagram of examining housing typology in green roofs.

Design Elements

- At the center of this gargantuan undertaking is located on highly dense urban area. The grassy slopes of the large lawn area were created by stacking blocks of Styrofoam, used as fill to reduce weight then covering the blocks with of planting soil.

- The ramps, walkways and plazas paved with Sierra granite, were also built over Styrofoam fill (Taut, 2010).

- The trees, vegetated terraces and green roof top structure rest on the columns of the pedestrian walkway.

- The trees are anchored by guy wires attached to concrete deadman. Furthermore, the smaller courts and gardens are planted with evergreens and flowering trees; a garden of mounded beds featuring weeping willows, a rhododendron garden, and a crab apple orchard with a sitting area are special features of the development.

- The building and squares were designed to complement each other, with planted terraces overlooking the rooftop plaza. The central terrace is almost surrounded by plantings of crab apple and ivy. (Kolb, 1984).

- This quiet shaded residential complex includes seating on permanent benches. The pool on the top of the granite slab in foreground reflects the feeling of repose in this area.

- The connected bridge over the pool function as continuations between the two courtyards.

- Ground covers including grass, Baltic ivy, pachysandra and ajuga, plus seasonal annuals and bulbs are used extensively (Wirth, 1977). A variety of trees and flowering shrubs provide additional colour as well as shade.

- The elevated pedestrian street is paved with a layer of two color Venetian terrazzo, which lies on a top reinforced-concrete slab of the underground parking below.

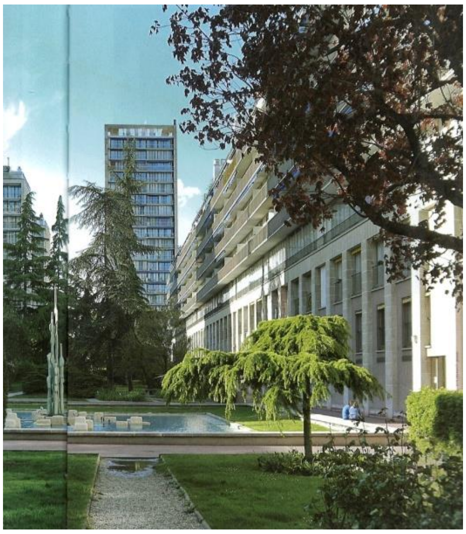
- The fountain basins are of polished dark green terrazzo laid over the concrete (ibid). Along the perimeter of the main courtyard are walks, permanent benches and plantings, all facing the central fountain.

- Although the bridge, which is located above the ornamental pool carries little pedestrian traffic, its permanent benches provide additional spaces for sunning, resting and conversation.

Evaluation

Elevated Green Street

Terrace trees provide multiple benefits in this intensively housing design. Ecologically, they enhance local habitat conditions and reduce the urban heat island effect by shading pedestrian walkways and sidewalks, thereby reducing the heat gain of these areas during sunny days. Functionally, they can provide both visual and physical distinctions between corridor uses by separating outdoor traffic, which leads to air pollution and supply fresh air into the living spaces (see figure 3.43 and 3.44).

	
Figure 3.43: Connected Bridge View. (a&t Research Group, 2013, p.290)	Figure 3.44: Sculptured Water Park. (a&t Research Group, 2013, p.291)

Green Terrace

This residential complex is a quiet place full of good people. Bernard (2011) claims that where neighbourhood life goes on free and easy, without fences. Within these monumental voids, green pedestrian walkway is a distant murmur and glimpses of the street appear through horizontal vegetated surfaces. In the midst of this peace and green tranquility, it is the complex, which reveals itself and speaks directly about the sustainability.

3.2.5. The Barbican Complex-An Exquiste Ghetto

The Barbican estate is located within the City of London, an area which in the mid 19^{th} Century had started to lose population due to an increase in office and land use (see figure 3.45 and 3.46), (Heatcothe, 2011).

Figure 3.45: Through the view of culture center and 43 storey residential tower. (Ozarisoy, 2013)

Figure 3.46: Through the view of podium, underground car park entrance and terrace houses.(Ozarisoy, 2013)

The City of London reveals that for the final solution for the Barbican, five different mixes were introduced for the layout. The first was direction related, mixing blocks with towers. The second was typology related, combining high-rise access shafts with green passageways, with communal vegetated terraces for two dwellings per floor and loggia houses. Thirdly the option of the semi-block aligned to the road in some cases and in other cases integrated into the network of green pedestrian walkways within the connected podiums. Fourthly, mixing private, semi-public and public open spaces with water features, vegetation and hard pavements. Finally, mixing education and culture related uses into the residential programme with a drawing power, which reached far beyond the sphere of the local area (Harwood, 2011).

Main Findings

Plan for rebuilding central London employed the idea of the green roof design in which every action included residential buildings in a semi-closed block within an environment of pedestrian circulation spaces divided off from the new roads being built (see figure 3.47 and 3.48).

	
Figure 3.47: Connected Podium and Elevated Street. (Grandorge, 2009, p. 242)	Figure 3.48: Inner Courtyard is surrounded by row houses on the ground then above row houses and penthouses. (Grandorge, 2009, p. 242)

The green urban strategy, which is most noticeable in the Barbican, design is that involving the green terraces, roof top gardens, vegetated podiums and conservatory for an artificial forest (see figure 3.49).

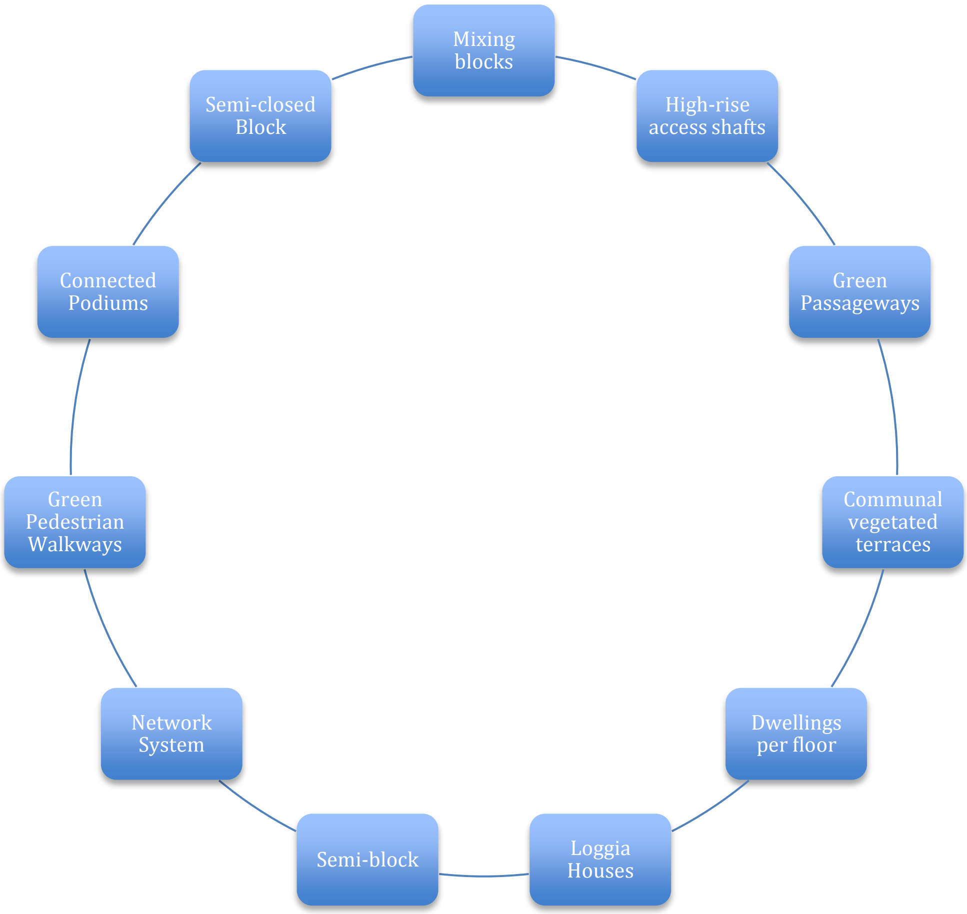


Figure 3.49: The evaluation of the residential complex.

Typology of Residential Units

The Barbican Estate comprises 18 residential blocks and three towers. The largest apartments are located on the south side. On the north side there are more one or two bedroom apartments (see figure 3.50). The other types vary according to the orientation of each block (Chamberlin, 2011).

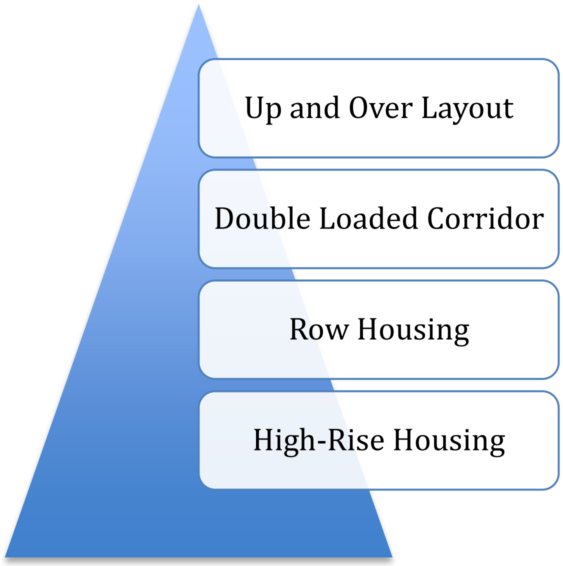


Figure 3.50: The diagram of examining housing typology in green roofs.

Block With An Up and Over Layout

The dwelling type of the block located East of the site, facing the narrow Moor Lane, is characterized by its being built on three levels with a front to back layout (see figure 3.51 and 3.52).. Additionally, the main aim is to make living rooms face west direction, overlooking the communal garden towards adjacent roof top garden, and the bedrooms look onto the street. For this reason, the dwellings are front to back, going from one orientation to another. Access is via central green corridors located on alternate levels. The long horizontal vegetated balconies use as a social gathering area for residents (see figure 3.53 and 3.54).

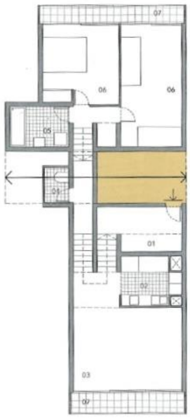
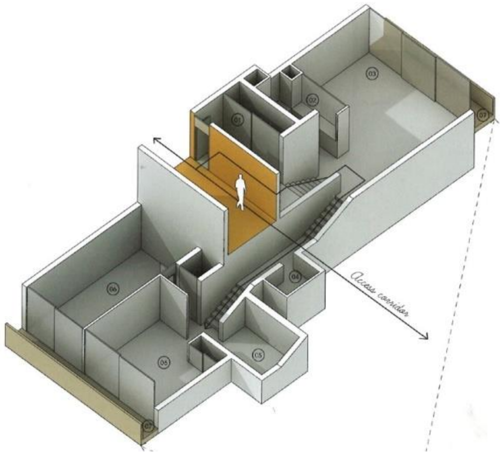
	

Figure 3.51: Up and Over Layout - Dwelling Type Plan. (Grandorge, 2009, p. 258)	Figure 3.52: Isometric view of dwelling type. (Grandorge, 2009, p. 258)

	
Figure 3.53: Terrace Houses which is raised on the Roman types of columns. (Ozarisoy, 2012)	Figure 3.54: Terrace Houses, which is faced to the courtyard. Closed car park is also located on under the green roof park. (Ozarisoy, 2012)

Block With Double Loaded Corridor

The majority of blocks have a central corridor on each floor. In this case there are two dwellings, on to the northwest and the other to the southeast on both sides of a central corridor running through the building (see figure 3.55 and 3.56). This complex is six storeys high with garden flats beneath the pedestrian podium, which runs around the whole building (Chamberlin, 1959). On the podium level there are vegetated gardens providing access to two dwellings per storey (see figure 3.57 and 3.58).

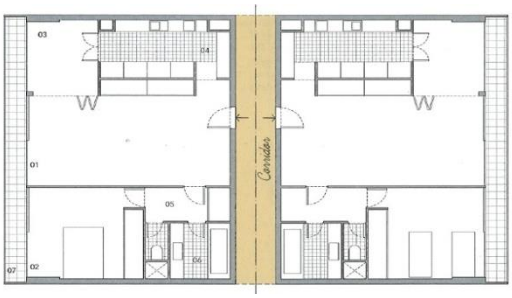
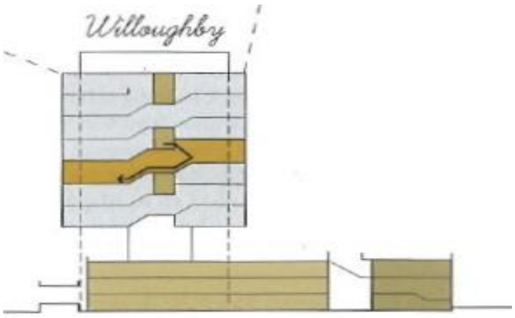
	

Figure 3.55: Double Loaded Corridor Block- Dwelling Type Plan. (Grandorge, 2009, p. 263)	Figure 3.56: Section of terrace houses. (Grandorge, 2009, p. 259)

	
Figure 3.57: Terrace houses, which are faced to the main amphitheatre and communal garden. (Ozarisoy, 2012)	Figure 3.58: Terrace houses, which are faced to the main street. (Ozarisoy, 2012)

Row Housing

Apart from the aforementioned examples, there are also the so-called garden flats, located underneath the podium, at lake or garden level. The layout is a line of twenty-six two- storey row houses. Access is by going down from the public podium. The interior solution adopted for the end dwellings is a split-level living area and accessibility to the roof garden (see figure 3.59 and 3.60). Most of the ground floor is raised in relation to the level of the lake (see figure 3.61 and 3.62).

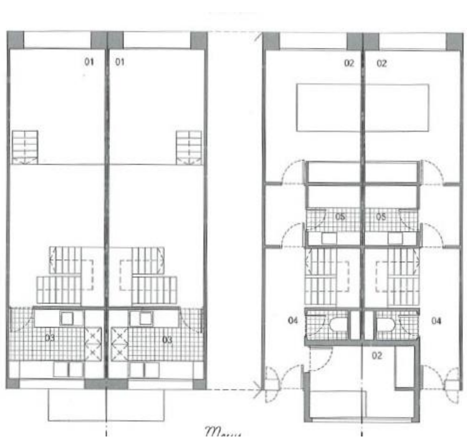
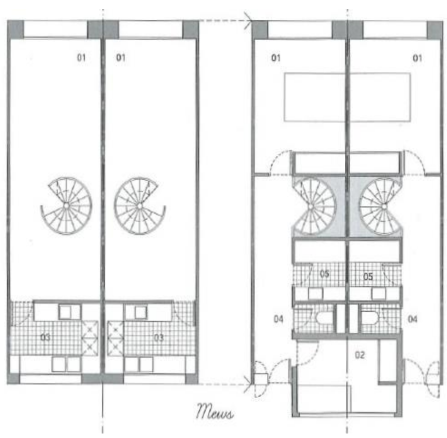
	

Figure 3.59: Garden Flats A – Typical Units. (Grandorge, 2009, p. 265)	Figure 3.60: Garden Flats B – Typical Units. (Grandorge, 2009, p. 265)

	
Figure 3.61: Row houses, which are faced to the inner courtyard. (Ozarisoy, 2012)	Figure 3.62: Row houses and their site-parking view. (Ozarisoy, 2012)

High-Rise Housing

There are three tower blocks with a polygonal floor plan. Cromwell Tower, located further north, is 43 storeys high above the podium. The other two, Shakespeare Tower and Lauderdale Tower, are 44 storeys high. The floor plan for each comprises three dwellings, each with a different orientation (Borthwick, 2011). The three high-rise towers are similar in terms of layout (see figure 3.63). The only variation is the use of the final rooms, in some cases bedrooms, in other cases living rooms, whereby the orthogonal shape is altered due to the requirements imposed by the triangular geometry of the floor plan (see figure 3.64 and 3.65). Orientation varies from one tower to another so that all rooms receive sunlight at one point in the day. Access to each tower block is produced in a different way such as elevated green street or green connected podium.

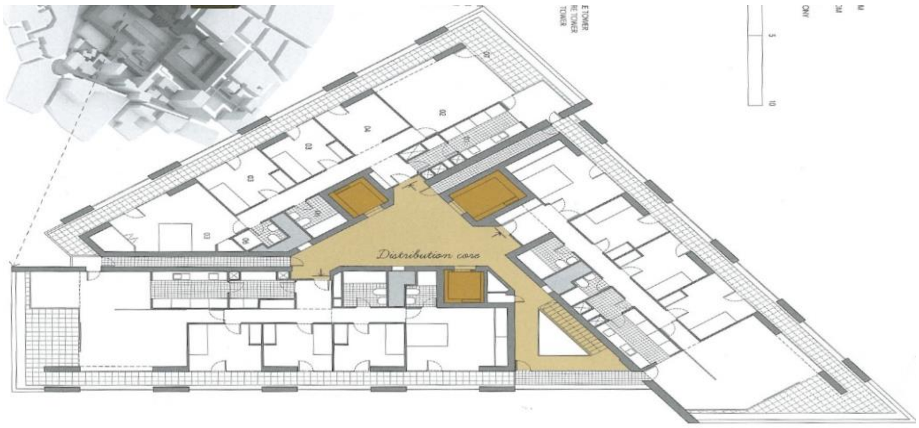


Figure 3.63: Tower – Typical Units Plan. (Grandorge, 2009, p. 267)

	
Figure 3.64: Through the view of Residential tower and its pedestrian bridge. (Ozarisoy, 2012)	Figure 3.65: Through the view of residential towers. (Ozarisoy, 2012)

Design Elements

- Trees and shrubs were ruled out because of the quantity of soil needed for root support. In their place, four large and five small pipe sculptures were arranged on the roof for vertical interest.

- A surface of finely textured mauve-colored gravel supports a grid of red-brick pavers. Low wooden planters containing colorful annuals and low growing junipers from a permanent parterre bordering the sculptures (Scalbert, 2011). These planters originally contained only junipers, which did not all thrive and so were replaced.

- Permanent metal benches and raised concrete-block planters faced with dark wooden lattice edge the perimeter of the space.

- The roof garden's hardscape is largely concrete and interlocking red-brick paving, which is used throughout in appropriate paving patterns, as well as for raised beds, a bridge and ramps.

- The dominant trees used in the raised beds are exceptionally well shaped specimens of coral trees.

- Access to the plaza is via the residential tower entrance, the podium bridge from the motorway, the car-park below and by steps and spaces with suitable furnishings for informal gathering available (Risselada, 2004).

- Tables and chairs are provided at the main square nearby the artificial lake and connecting bridge to the residential buildings.

- It is interesting to note that the edges of huge planters are too high to sit upon; the benches near the fountain have no backs and outdoor furniture has not been provided in the primary garden area, which is located on nearby the ground row houses. This space would surely benefit from the installation of comfortable garden furniture that would add human scale to the imposing features now in place.

- This green roof space serves as such a major pedestrian point of entry during the day, the steps and the adjoining podium are alive with people socializing, resting, sunning or simply moving from place to place.

- The garden features an outdoor eating area, a reflecting pool that flows to a waterfall flanking the connected bridge over the artificial lake and plenty of wooden benches with tables for comfortable seating.

- The secondary area, off to one side of the main square has similar paving. Intended as a separate, more private area for residents to use for socializing outdoors, it was supposed to be furnished with garden tables, umbrellas and chairs.

- The entire area is quiet except for the sound of the splashing fountain. The water and electricity supply lines, as well as drainage, are all carried in the ceiling of the underground car-parking below, penetrating the slab to the garden level where needed (Risselada, 2004).

- It is interesting to note that a major walkway that meanders from the residential towers off site to the row houses includes a number of branches that connect to city sidewalks. Along this walk are benches, fountains, pools and waterfalls, in a setting of large evergreens and deciduous trees.

- Furthermore, flowering perennials and annuals give the garden exciting splashes of colour.

Evaluation

Connected Podium

The entire built environment in the Barbican is erected on a platform, the podium, which becomes the access base for the buildings. This elevated stage functions as a pedestrian street and also serves as a socialization area. For this reason, the ground floor in contact with the terrain does not correspond to the area where urban life takes place, which is on the upper level (see figure 3.66 and 3.67). The construction of a perimeter podium is one of the estate's most characteristic and controversial features because of the way it divides off the streets from the perimeter.

Reyner (1976) mentioned that constructing a perimeter podium is exaggerated by the different level between the north and south ends of the estate made it necessary to raise the podium by 3 meters on the north side due to the topographical characteristics of the land. Within the site, space flows from East to West under the large columns which support some of the housing blocks.

	
Figure 3.66: Connected podiums provide access to the residential towers and terrace houses. (Ozarisoy, 2012)	Figure 3.67: Through the view of connected podium. (Ozarisoy, 2012)

Elevated Green Street

An elevated green pedestrian street, the high walk, runs throughout the estate and links it to the adjacent buildings. Access to the residential tower blocks is via the podium or from the car park. The idea of burying roads and elevating pedestrian walkways allows for the uses to be stacked even though the estate functions on a separate level to the surrounding streets. There is a staggered section in the volume going down towards the street and one can understand how the high walks which run through the whole estate actually work efficiently (see figure 3.68 and 3.69). The elevated green pedestrian street becomes the real reference level and provides access to the vertical circulation cores of the blocks and to the row houses from the connected bridges.

	
Figure 3.68: Connected Roman type pedestrian bridge under the terrace houses. (Ozarisoy, 2012)	Figure 3.69: Vegetated connected podium provides access to the residential buildings. (Ozarisoy, 2012)

Water

The use of the residential complex is varied despite, being a prevailing purpose of green terraces, vegetated balconies, green roof top gardens and green podiums. All this is integrated into a set of open spaces, which interconnect at different levels with alternating hard and soft surfaces. Water, a feature which reappears in this complex, is represented here in a small pond (see figure 3.70 and 3.71).

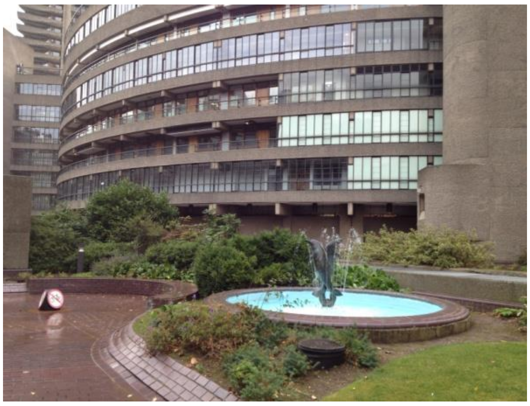


Figure 3.70: Sculptured water element is integrated on the vegetated roof. (Ozarisoy, 2012)	Figure 3.71: Semi-circular water pond which is the main part of the artificial lake. (Ozarisoy, 2012)

3.3. Summary of the Chapter

From the evaluation of the examination of green roofs residential buildings in all these five high density urban perimeter blocks, it can be concluded that generally, the arrangement of green roofs shows similarities in terms of applying their design elements. The planting variety, plant containers, paving surfaces, furnishings, lighting, shelters, sculpture and water elements are examined on under the residential building typology. These are the main parameters to contribute the basis of green roof designs. These green roof elements show similarity in terms of their construction system and materiality. These five selected residential complexes are mainly constructed concrete and used green vegetated surfaces on different spatial organization of the buildings. This leads to change the character of buildings thus designing their building typology within the additional green spaces. However, the arrangement of green roofs shows variations according to residential unit design. This includes green deck, elevated green street, green community corridor, green terrace, horizontal green balcony, loggia and connected podium. In general, these green roof concepts create green continuity between indoor and outdoor spaces of residential units.

Chapter 4

CONCLUSION

The greening of rooftops is a way of researching the landscape. The definition of the existing landscape to amplify its character through substraction and modest basis which has been throughly calculated, to resist any form of over simplification of nature and landscape. Across the site and how we might intensify the perception of these living entities through careful strategies. All of these insights are a given idea to gain a better understanding. It is a most visible expression of the imposition of enlightened order on the land which enhance the powerful expression of nature. All disciplines involved in the roof top design need a deeper understanding and recognition of the functional performance and values of greening and how to put them in practice.

In this research, green roofs initially have been discussed in Chapter 2. Examining theoretical framework of green roofs continued with deriving a methodology for their design elements, including the role of green roof, space strategy for green roof, landscape form, history of landscape and green roof then follow up green roofs for different building types and their design elements. This information has been moved to Chapter 3 in order to be able to decide the most appropriate green roofs and their design elements in residential buildings. The selected high density residential blocks as examples have been analyzed and illustrated for using the best examples of green roof design elements. After the literature survey, residential buildings have been chosen as a case study. The evaluation of 5 case studies on residential building has shown that the differences and similarities of green roofs and their design elements how they implement the housing spatial organization. Accordingly in Chapter 3 the main findings about this research discussed in detail.

Interpretations of the Design of Green Roofs in Residential Buildings

The green balcony, terrace, loggia or roof is a desirable requirement in the contemporary world. The lack of such exterior space has the most common dissatisfaction with an apartment. A loggia or a balcony is thus more than a room with a view, not only extends the apartment but makes it whole in the first place giving the residents the feeling of openness and freedom.

In multistory apartment buildings, greening the exterior areas enrich a home and improve its quality and use of value. Consequently such outdoor spaces always top the lists of most hunted apartments. Builders and marketers have long since recognized this and thus a connection to green space is always emphasized to good effect. Exterior spaces are a selling point on the housing market, intended to motivate renters and buyers to dig more deeply into their pockets than they had intended and put up with high prices or other economical disadvantages.

Nevertheless, the outdoor space offered is not always adequate, since even a spacious loggia or generous balcony represents a modest space in comparison to the garden of a freestanding single-family home. The desire to spend time in a green space is the root both of the sized gardens of row houses and the flight of city dwellers to greener areas in the form of ecological design. Despite this objection, it is both presumptuous and wrong to play off an individual's legitimate desire to own a home in a green space against an outdoor area of a multistory apartment building.

The obvious comparison and juxtaposition of outdoor space and garden simply make no sense. However, describing outdoor space in the urban context of a multistory apartment building in terms of its own qualities is the goal of this dissertation. The inventiveness of architects has ensured that the design of outdoor spatial compartments offers a broad, increasingly diverse spectrum.

From the evaluation of the examination of green roofs of residential buildings in all these five high-densely urban perimeter blocks, it can be concluded that generally, the arrangement of green roofs shows variations according to residential unit design. This includes green deck, elevated green street, green community corridor, green terrace, horizontal green balcony, loggia and connected podium. In general, the landscape areas have been observed both indoor and outdoor as part of the residential units to understand their integrity in between man-made and the natural environment (see figure 4.1).

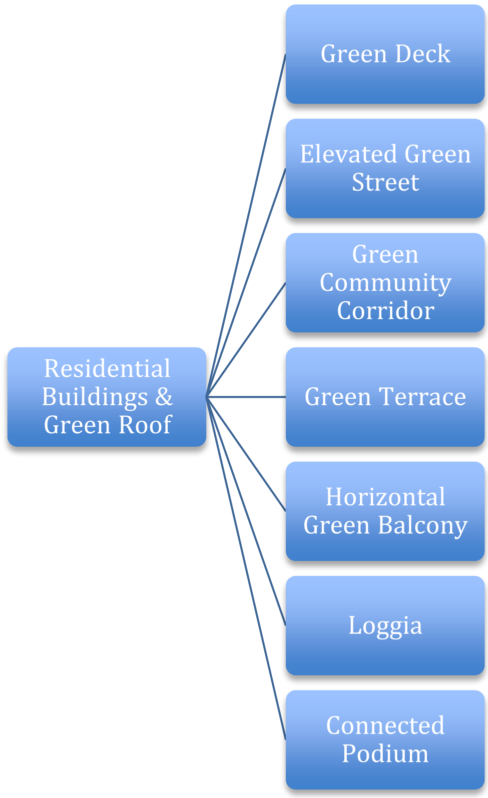


Figure 4.1: The main findings on green roof design approaches in residential buildings.

Interpretations of Green Roof Design

Green cities facilitate and encourage more green roof designs and healthy lifestyles. Green areas have an important role in providing services such as potential for recreation and commuting routes in an attractive environment. In a green city, green areas are diverse and functional, from an ecological as well as experimental point of view. The biodiversity concept should be expanded in an urban setting to signify and include an array of recreational possibilities for its residents and provide the potential to experience different forms of landscapes. This requires that the green areas be located in the right places according to local cultural and ecological values, sufficient in size, access and frequency. They also need to possess characteristics of a healthy ecosystem.

Green areas promote environmental concerns and respond to climate change issues in various other ways too. They provide cooling of the local climate, cleaning and filtering of water and air, habitats for bio diversity and biomass for carbon sinks. They also make buffer zones for detention and flood control by providing large areas of unpaved, absorbing and filtering surface in the urban setting.

The construction of sensuous ecologies involves the rigorous integration of inherent site conditions into the green design process. Including the ecological systems, bio-organic and natural processes and energy flows that occur in and around the site. This process generates innovative and optimally performing design solutions through the development of symbiotic relationships and connections among the variant and seemingly independent processes of the users, the built environment and the natural environment. Constructing sensuous ecologies results in the development of sensitive and engaging constructed habitats that evolve the social, economic and natural ecologies of their contextual sites.

A Green roof strategy is not the only solution for improving the quality of the existing environment but is suggested as a lucrative and feasible solution for it implementation of new projects. Designers have a much wider responsibility for the environment enveloping our architecture – the air, water, earth and climate – before designers even start consolidating buildings and internal conditions (see figure 4.2).

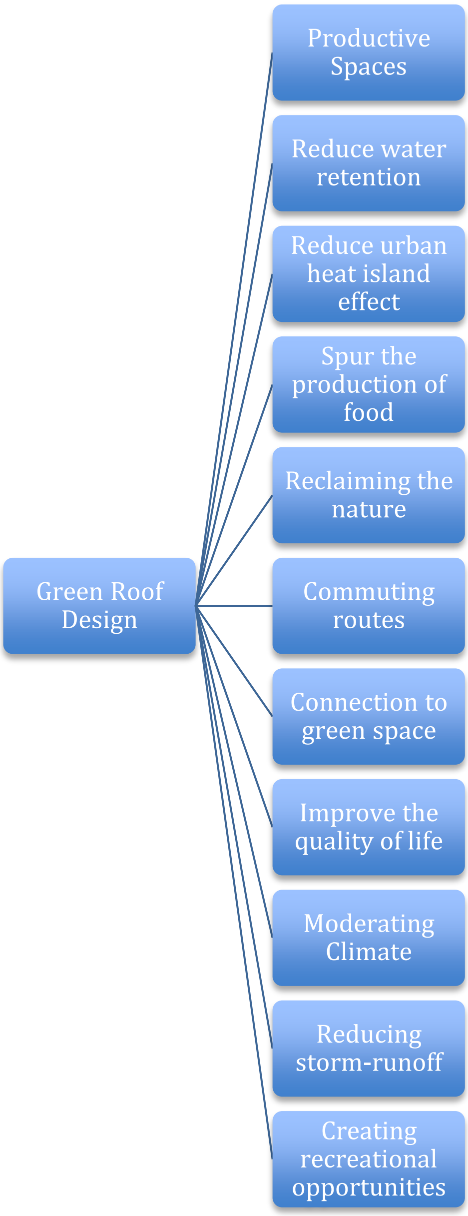


Figure 4.2: The main findings on green roof designs.

The environmental benefits are mainly based on improving air quality, moderating climate and reducing storm runoff and offering a wide range of opportunities to increase green spaces in urban areas. Moreover, it is also a remedy for the heat island effect, creating recreational opportunities and increasing the quality of a roof's life. The main concern and predominant issue in greening a rooftop design, is essentially one of effective integration of the environment and sustainability. The consideration of offering certain solutions is important because it enables us to focus on all of the benefits on fulfilling the single objective of an environmental integration.

This research has shown that green roof design elements have made great changes on housing typology. The world problems such as overcrowding, loss of agricultural productivity, overloading of the transportation systems, housing shortages and air pollution and are all factors that all have negative impacts on the environment. These problems are integrated with the green roof design therefore a green roof can be one solution to address these problems. The examination of five residential buildings shows that using green spaces improves the environment and also the quality of life of the residents living in high density buildings.

This study seeks to benefit students, researchers, designers, urban planners, landscape architects and architects who want to adapt ‘green roof’ into their designs whilst seeking to create a more healthy environment.

REFERENCES

Academy of Urbanism, (2010). “ The Freiburg Charter for Sustainable Urbanism”.

AIJ (Architectural Institute of Japan), (2005). Architecture for a Sustainable Future-All About The Holistic Approach in Japan, IBEC.

Alain, R., (1997). “Court traite du paysage”, Recovering Landscape, p.8.

American Society of Landscape Architects, (2009). “The Case for Sustainable Landscapes”. ASLA, Washington DC.

Backman M., (2008). Asia Future Shock: Business Crisis and Opportunity in the Coming Years, New York, Palgrave MacMillan.

Baker, M., (1980). “New Roofing Systems.” Canadian Building Digest, January 1964, p.49. Roofs: Design, Application and Maintenance. Montreal: Multi-science Publications.

Banham, R., (1976). Megastructure. Urban Futures of the Recent Past. Harper & Row. Londres. 1976.

Barbican. Listed Building Management Guidelines, (2012). Volume I. Originally published 24th May 2005.

Beardsley, J., (1998). "Earthworks and Beyond: Contemporary Art in the Landscape", Abbeville Press, New York.

Berghage, R.D., (2005). Quantifying Evaporation and Transpirational Water Losses From Green Roofs and Green Roof Media Capacity and Neutralizing Acid Rain, Penn State University, University Park, Pennsylvania.

Bohigas, O., (2009). "Spazio Collecttivo ed Edifici Residenzali, Il Progetto Urbano Come Architettura della Citta, in ed. Luisella Gelsomino and Ottoriono Marinoni, Bologna: Editrice Compositori.

Borthwick, G., (2011). Barbican: A Unique Walled City Within the City. University of Edinburgh.

Boyer, C., (1996). Cybercities, USA: Princeton Architectural Press.

Callender, J., (1982). Time-Saver Standards for Architectural Design Data. 6^{th} ed. New York:Mc-Graw-Hill.

Capra, F., (2003). The Hidden Connections: A Science of Sustainable Living, Flamingo, UK.

Carter, E., (1962). The Future of London. Penguin Books.

Chamberlin, Powell and Bon, (1982). Barbican, London. The Urban Enclave. De Stadsenclave. DASH 5. NAi Publishers, 2011, p.120-131.

Chamberlin, Powell and Bon, (1959). Barbican Report 1959. Barbican Committee, Corporation Of London.

Chapron, A. and Charles F, (2003). Fernard Pouillon, architecte. Editions du Pavillon de l' Arsenal, 2003. P.146-147.

City of Vienna, (2007). "Vienna Environment Report",p.90.

Corner, J., (1999). "Ecology and Landscape" Recovering Landscape, p.14.

Cuito, A., (2000). Ecological Architecture: Bioclimatic Trends and Landscape Architecture in the Year 2001, Loft Publications, Barcelona Spain.

Darbourne, J., (1968). "Roof Gardens for a Local Authority." The Architect's Journal (London).

Delleuse, H., (2001). In Jean-Lucien Bonillo. Fernard Pouillon, Imbernon.

Dines, Nicholas, and Charles H., (1997). Time Saver Standards for Landscape Architecture. 2d ed. New York: McGraw Hill.

Donella H. Meadows et al., (1972). The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind .New York, Universe Books.

Dunnett, N., Kingsbury, N., (2004). Planting Green Roofs and Living Walls. Timber Press, Portland OR.

Durand, N., (1981). Lecciones de Arquitectura. Lamina 15. p.81.

Ebner, P., (2009). Living Streets Wohenwege. Springer, p.40.

Finkel, Irving L., (1988). "The Hanging Gardens of Babylon." In the Seven Wonders of the Ancient World by Peter A. Clayton and Martin J. Price, 38-58. New York: Dorset Press, 1989; London: Routledge.

Francois, J., (1995). "The Propensity of Things: A History of Efficacy in China", New York: Princeton.

Frey, H. (1999). Designing the City: Towards a more sustainable urban form, E&FN Spon, UK.

French, H., (2008). Key Urban Housing of the Twentieth Century: Plans, Sections and Elevations. W.W Norton & Company.

Gedge, D and G Kadas. (2005). "Green Roofs and Biodiversity", Biologist.

Giedion, S., (1941). Space, Time and Architecture. Cambridge, MA: Harvard University Press.

Gilbert, O., (2012). The Ecology of Urban Habitats, Chapman & Hall, London.

Glass, J., (2001). Ecoconcrete, British Cement Association, Berkshire, UK

Goede, S., (2009). Justus Van Effen: Transition from identical interventions to regular Maintenance. Conserving Architecture, Planned Conservation XX Century Architecture Heritage, Editor A. Canziani. Electa, 2009.

Goode, D., (2006). "RECEP Urban Environments Desk Study: Green Infrastructure", Royal Commission on Environmental Pollution, London.

Gro Harlem Bruntland and World Commission on Environment and Development, (1987). Our Common Future, Oxford: Oxford University Press.

Hagan, S., (2001). Taking Shape: A new contract between architecture and nature, Architectural Press, Oxford, UK.

Hagan S., (2001). Taking Shape: A New Contract Between Architecture and Nature Oxford, Architectural Press.

Halliday, S., (2000). Green Guide to the Architect's Job Book, RIBA Publications, London, UK.

Harwood, E., (2011). Chamberlin, Powell & Bon. RIBA Publishing.

Hassel, M V.,(2005). “Community Gardens in New York City: Place, Community and Individuality”, MIT Press, London.

Heathcote, D., (2004). Barbican. Penthouse over the City. Wiley.

Hicks, P., (1965). Landscape on Top of Underground Garages. Landscape Design.

Howard, E., (2012). Garden Cities of Tomorrow. CreateSpace Independent Publishing Platform.

Hui SCM, (2006). Benefits and potential applications of green roof systems in Hong Kong. In: In Proceedings of the 2nd Megacities International Conference 2006, 1-2 December, 2006. P. 351-60.

Imbert, D., (1993). “The Modernist Garden in France”, USA:Yale University Press.

Jellicoe, S., (1975). The Landscape of Man. London: Thames and Hudson.

Kadas, G., (2004). “Rare Invertebrates Colonizing Green Roofs in London”, Urban Habitats.

Kahn, E., (1992). A Vase of Country Flowers. Landscape Architecture.

Koolhaas, R. and Chris, H., (2011). Project Japan. Metabolism Talks, Taschen.

Kolb, Walter and Tassion S., (1984). The Extensive Planting of Roofs. Garten +Landschaft.

Lagadec, E., (2010). Strategy of Sustainable Development Division Director, Paris Agency of Urban Ecology.

Leupen, B., (2006). Frame and generic space. A study into the changeable dwelling 010 Publishes.

Levinson, N., (1992). Cure for the Common Condo. Landscape Architecture, September 1992.

Lootsma B., (2000). Super Dutch, Thames & Hudson, London.

Liu KY, (2005). Using Garden Roof Systems to Achieve Sustainable Building Envelopes, Construction Technology Update, No.65, Institute for Research in Construction, National Research Council of Canada.

Lucan, J., (1982). Realisations de Jean Renaudie et interview. Architecture Movement.

Lowenthall D., (1985). “The Past is a Foreign Country”, London: Cambridge University Press.

MacDonald, K., (1963). “Suspended Deck Used in Roof-top Design.” Landscape Design and Construction, July 1963, 12-13.

Maki, F. and Masato, C., (1960). Some Thoughts on Collective Form. Metabolism.

Marot, S., (1999). “ The Reclaiming of Sites”, Recovering Landscape.

Marrey, B., (2011). Fernard Pouillon. Mon ambition. Editions du Linteau.

McGarvey, R., (2004). ‘Energy: Powering the Recovery’, in Harvard Business School.

Ministry of Construction, (1998). Housing Demand Survey, Tokyo, MLIT.

Morgan, W., (1972). “Buildings as Landscape: Five Current Projects by William Morgan.” Architectural Record.

Newton, J, D Gedge, P, Early and S Wilson., (2007). Building Greener: Guidance in the Use of green Roofs, Green Walls and Complementary Features on Buildings, CIRIA, London.

Nicol, L., (2012|). Sustainable Collective Housing: Policy and Practice for Multi-family Dwellings. Routledge.

Osmudson, T., (1997). “Roof and Deck Landscapes.” In Tame Saver Standards for Landscape Architecture, edited by Nicholas Dines and Charles W. Harris. 2ed. New York:Mc-Graw-Hill.

Packard, T., (1981). Architectural Graphic Standards. 7th ed. New York: John Wiley and Sons.

Pellet, H., (1976). “Use of Aboveground Containers in Landscaping Problems Associated with Winter Soil Temperatures.” Miscellaneous Arboretum, University of Monnesota Agricultural Experiment Station.

Porteous, C., (2001). The New Eco-Architecture: Alternatives from the Modern Movement, London, Spon.

Powers, A., (2010). Robin Hood Gardens: Revisions: Twentieth Century Architecture, Paul Holberton, Publishing.

Prescott, W., (1966). The History of the Conquest of Mexico. 1842. Reprint (abridged). Chicago: University of Chicago Press.

Register, R., (2002). ‘Ecoscape Eco Industry Eco Culture’, Proceedings of the Fifth

International Ecocity Conference, The Fifth International Ecocity Conference, Shenzhen, China, August 19-23, 2002, Ecocity, USA.

Register, R., (2006). ‘Ecocities: Rebuilding Cities in Balance with Nature’, New Society Publishers, Canada.

Retzlaff, W., (2007). A Guide to Rooftop Gardening, Southern Illionis University, Edwardsville.

Risselada M., (2004). From a House of the Future to a House Today. 010 Publishers.

Robinette, G., (1968). “Plants: The Natural Air Conditioner.” Landscape Design and Construction.

Rogers, R., (1974). Rooftop Development. In Handbook of Landscape Architectural Construction, edited by Jot D. Carpenter, 1-12. Washington, DC: Landscape Architecture Foundation.

Rossi, A., (2006). L’Architettura della Citta, Torino, CittaStudi.

Rygaard, M., (2011). Increasing urban water self-sufficiency: New era, new challenges. Journal of Environmental Management 2011; 92(1): 185-194.

Scalbert, I., (2011). The architect as bricoleur. Candide 4. Journal for Architectural

Knowledge.

Scalbert, I., (2004). A Right to Difference. The Architecture of Jean Renaudie. Architectural Association.

Schofield, H., (2010). Paris fast becoming queen bee of the urban apiary world. BBC News. Aug 14.

Schonholzer, P., (1968). “Roof Gardens in Industry.”, Anthos.

Scrivens, Stephen and P. Cooper, (1980). “Irrigation 1.” Architects’ Journal Technical Study: General Principles.

Siessor C., (1997). Eco-Tech: Sustainable Architecture and High Technology (London: Thames&Hudson, 1997).

Simithson, A., (1974). Team 10 Primer. The MIT Press, 1974, p.78.

Sitta, V., (1983). A living Epidermis for the City. Landscape Australia.

Slobodkin, L.B., (2003). A Citizen’s Guide to Ecology, Oxford University Press, UK.

Southard, T., (1968). “Living off the Ground”. The Architects’ Journal, London.

Stone, D., (2006). “Health and Nature: Critical Elements for Sustainable Developments”. In E. Williams(Ed) Proceedings of the 22nd Conference of the Institute of Ecology and Environmental Management 2005. Sustainable New Housing and Major Developments –Rising to the Ecological Challenges IEEM, Winchester, pp 61-66.

Sutro, D., (1992). “Bloom Service.” , Landscape Architecture.

Teemusk, A., Mander, U., (2007). Rainwater runoff quantity and quality performance From a green roof: the effects of short term rain events. Ecological Engineering 30, 271-277.

Truex, P., (1969). “Confiners in the Winter Roof Garden.” Horticulture, January 1969, 44-45.

Tuluca, A., (1997).Energy Efficient Design and Construction for Commercial Buildings, McGraw-Hill, New York, USA.

United Nations, (2011). World Urbanization Prospects. The 2010 Revision. Highlights. UN, New York.

United Nations, (2005). World Population Prospects: The 2004 Revision. CD-ROM Edition –Extended Dataset, United Nations, New York.

Unwin, R., (2010). Town Planning in Practice: An Introduction to the Art of Designing Cities And Suburbs. FQ Legacy Books.

URBED, (2004). “Biodiversity by Design A Guide for Sustainable Communities”. Town and Country Planning Association, London.

Wagoner, J., (1998). “Protected Membrane Roofs.” In Roofing and Waterproofing Manual 4th ed. Rosemont, IL: National Roofing Contractors Association, 1998.

Whalley, J., (1978). “The Landscape of the Roof.” Landscape Design ,London.

Wirth, E., (1977). Landscape Architecture above Buildings. Underground Space,

Yeang, K., (2005). “Green Design (a background report for The United Nations Forum On Energy Efficiency and Energy Security for Sustainable Development : Taking Collaborative Action on Climate Change, Seoul, Korea, December 2007).

Zhang X., (2011). Green Strategies for gaining competitive advantage in housing Development: a China study. Journal of Cleaner Production 2011; 19(2-3): 157-67.

Zion, R., (1986). Trees for Architecture and Landscape. New York: Van Nostrand.

APPENDICES

APPENDIX A:Table 1

DESIGN DETAILS OF ROOFTOP GARDENS

1.0 PLANTING VARIETY

 **Fig.1:**Constitution Plaza, Hartford, Connecticut **(**Sasaki Associates,1999,p.47)	• The court is planted with evergreens and flowering trees; a garden of mounded beds featuring weeping willows, a rhdodendron garden, and a crap apple orchard with a sitting area. • Ground covers, including grass, Baltic ivy, pachysandra and ajuga, plus seasonal annuals and bulbs, are used extensively.
 **Fig.2:**Kaiser Resources, Vancouver, Canada **(**Theodore Osmundsan Associates,1999,p.68)	• Comfortable furnishings and tubs with brightly colored masses of flowers enliven this end of the roof garden. • The principal plants throughout the space are rows of flowering crab apple trees, with evergreen used as a ground cover. • Seasonal annuals planted in portable round concrete plant tubs add color throughout the space.
 **Fig.3:**Kaiser Resources, Vancouver, Canada **(**Theodore Osmundsan Associates,1999,p.76)	• The sheltered redwood deck extends over the pond. With its comfortable outdoor furniture and flowers, it is an ideal space for conversation. • Trees were chosen for their dwarf and weeping characteristics to withstand the wind; they include Canadian hemlock, golden thread leaf cypress, Japanese maple, weeping, Norway spruce and contorted beech.
 **Fig.4:** Harrison Memorial Hospital, Bremerton, Washington	• The designed effect has been partly realized with the new planting. As the small, multi-textured ground covers spread and the grasses grow in height, the continuity and contrast within the garden will increase. • The small and delicate plants set against stone, river rocks and redwood provide harmonious but dramatic contrasts.

(EDAW Project Design, 1999,p.127)	

APPENDIX A:Table 2

DESIGN DETAILS OF ROOFTOP GARDENS	
2.0 CONTAINERS	
 **Fig.1:** Union Bank Square, Los Angeles, California, 1999. **(**Harrison and Abramovitz, 1999, p.13)	• Striking raised beds on a grid pattern, planted with Bradford pears, constitute the principal design feature of plaza. • It is surrounded on three sides by high white precast-concrete walls that are relieved by a horizontal stripe near the top; these walls, along with rows of pin oak trees at street level.
 **Fig.2:** Bunker Hill Steps and 444 South Flower Terrace, Los Angeles, California. (Omi Lang Associates,1999,p.43)	• The plazas at each end of the long, narrow site feature a formal grid of raised planters of granite and white pre-cast concrete planted with trees and seasonal flowers. • The planters are insulated from cold and irrigated by overhead sprinklers.
 **Fig.3:** Federal Reserve Bank, Boston, Massachusetts. (The Stubbins Group, Boston, 1999, p.93)	• The edges of huge planters are too high to sit upon; the benches near the main lawn area have no backs and outdoor furniture has not been provided in the primary garden area. This space would surely benefit from the installation of comfortable garden furniture that would add human scale to the imposing features now in place.
	• Shade trees are planted in relatively small circular openings surrounded by concrete curbs. • The entrance to the roof garden is at deck level flanked by potted plants. Massive broadleaf trees are in permanent rounded concrete boxes.

Fig.4: Constitution Plaza, Hartford, Connecticut. **(**Sasaki Associates,1999, p.83)	

APPENDIX A:Table 3

DESIGN DETAILS OF ROOFTOP GARDENS	
3.0 PAVING AND WALKING SURFACES	
 **Fig.1:** Equitable Plaza, Pittsburgh **(**Simons and Simons Architects, 1999, p.133)	• The plaza is paved with layer of two color Venetian terrazzo, which lies on top reinforced-concrete slab, which in turns rests on the structural slab of the roof. • The paving finish is modeled after a rustic Venetian terrazzo, with four colors of marble chips, from Belgium, Italy and Maryland, set in mortar.
 **Fig.2:** Yerba Buena Gardens, San Francisco, California. (Omi Lang Associates, 1999, p.88)	• The ground surface is paved with compacted decomposed granite and broken stone that has a high content of fines. Its color and textured look provide a far more pleasing appearance than concrete does.
 **Fig.3:** Ark Hills Center, Tokyo, Japan. **(**Nishita and Carter ASLA, San Francisco, 1999, p.121)	• The paving of the plaza contains a patterned grid produced by contrasting shades of concrete and brick.
	• The garden replaces horizontal stripped wood coverage and a stone terrace with Cor-Ten steel stepped gardens and a colored concrete terrace perfect for users.

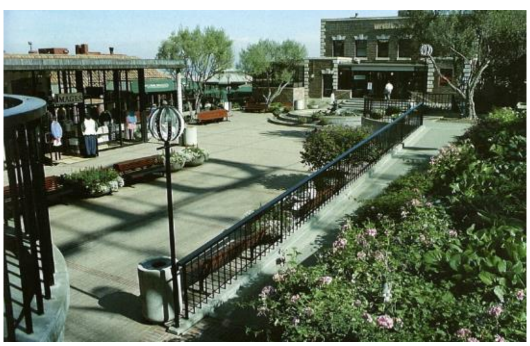
Fig.4: Munich Hospital, Munich **(**Gerhard Teustch Landscape Architect, 1999,p.53)	

APPENDIX A:Table 4

DESIGN DETAILS OF ROOFTOP GARDENS	
4.0 FURNISHINGS	
 **Fig.1:** Four Seasons, Mexico City Hotel, Mexico City **(**Arrandero, E., 1999, p.171)	• The spaces with suitable furnishings for informal gathering available. Tables and chairs are provided near the building entrance and connecting to the main square.
 **Fig.2:** Cambridge Center, Camridge, Massachusettes, 1999. **(**SWA Group, Landscape Architects, 1999,p.181)	• Seating consists of integral benches permanently attached to the broad tops of the raised planters. Although ideally suited for flexible arrangements. • Permanent benches, integral with their locations, provide places for quiet reflection and conversation.
 **Fig.3:** Kaiser Resources, Vancouver, Canada. **(**Thedodore Osmundson Associates, 1999,p.127)	• This seating area overlooks the docked replica of one of the residential and historical area in the harbor. • The provision of comfortable garden furniture invites small groups to gather for conversation.
 **Fig.4:** Federal Reserve Bank, Boston,	• The primary seating areas are well furnished, with the chairs carefully arranged when not in use. Unfortunately, there are no tables to complement those in the area.

Massachusetts (Robert Fager ASLA, 1999, p.129)	

APPENDIX A:Table 5

DESIGN DETAILS OF ROOFTOP GARDENS	
5.0 LIGHTING	
 **Fig.1:** Yerba Buena Gardens, San Francisco, California. (Mitchell, Giurgola and Associates,1999,p.104)	• Lighting is provided through eye level along all walks, in addition, separate mercury vapor lights are embedded in the soil to direct light upward into the branches of all planted trees. The lights turn on automatically when the light level drops enough to activate photoelectric cell.
 **Fig.2:** Mayor Ogden Plaza, Chicago, Illinois. (Lohan Associates, 1999,p.132)	• Low light fixtures attached to the planters reinforce the grid pattern used in the space. • Granite walls surrounding the plaza have embedded strip lighting, which provides of indirect light over the plaza floor.
 **Fig.3:** Ghirardelli Square, San Francisco, California. **(**Lawrence and Halprin Associates,1999, p.145)	
 **Fig.4:** California State Compensation Insurance	• The light towers emit a warm glow and are strategically placed around the park, inspiring creativity and intellectual challenge. • Lighting is integrated into the towers for safety and comfort. The light towers bring an iconic presence. The semi-enclosed space provides local workers and residents an intimate environment.

Building, San Francisco, California. (John Carl Warnecke and Associates, 1999, p.61)	

APPENDIX A:Table 6

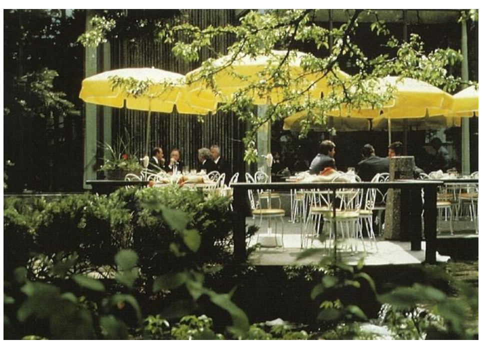
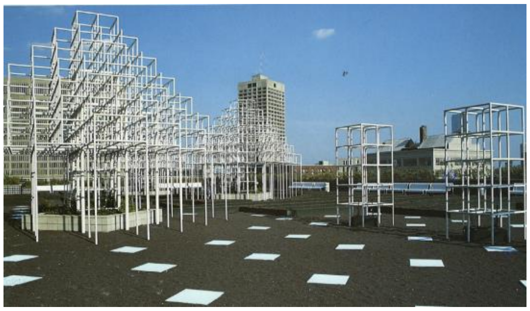
DESIGN DETAILS OF ROOFTOP GARDENS	
6.0 SHELTERS	
 **Fig.1:** Amoco Headquarters,Chicago **(**Jacobs/Ryan Landscape Architects,1999,p.117)	• The triangular form shaded structure serves as an outdoor activity areas within granite seating elements and a place of repose. Visitors moving toward the pavilion experience a spatial sequence of continual discovery and disclosure.
 **Fig.2:** North Linden Housing Project, Hannover,Germany. **(**Ruprecht Droge, Landscape Architect,1999,p.169)	
 **Fig.3:** Barney Allis Plaza, Kansas City, Missouri **(**The SWA Group, 1999,p.191)	
	• The wooden-structure pavilion is located at one end of the roof, with permanent tables adjacent. A sense of separation from the rest of the roof is suggested by the overhead shade structure. • The congregation area, sheltered by a roof and a variety of planting trees, offer pleasant places for users.

Fig.4: Mayor Ogden Plaza, Chicago, Illinois. (Lohan Associates, 1999,p.201)	

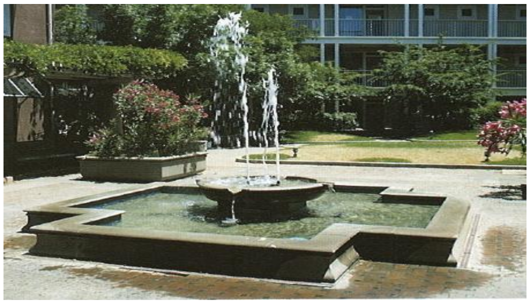
APPENDIX A:Table 7

DESIGN DETAILS OF ROOFTOP GARDENS	
7.0 SCULPTURE	
 **Fig.1:** Embarcadero Center, San Francisco. **(**SWA Group, Landscape Architects, 1999,p.142)	• A tilted water plane creates a dramatic entrance by presenting a false horizon and linking the bay to the city. Along the main square a promenade of trees passes through private garden rooms.
 **Fig.2:** Arco Headquarters, Chicago. **(**SWA Group, Landscape Architects, 1999,p.154)	• The central courtyard fountain, with short sculptural granite pylons and river stones in a paved area of granite sets.
 **Fig.3:** Embarcadero Center, San Francisco. **(**SWA Group, Landscape Architects, 1999,p.170)	• The settings are landscapes for sculpture, from large works to subtle time-based pieces. The relationship of sculpture, landscape and architecture is composed with a renewed enthusiasm.
 **Fig.4:** Cambridge Center, Cambridge, Massachusetts.	• Trees and shrubs were ruled out because of the quantity of soil needed for root support. In their place, four large and five small pipe sculptures were arranged on the roof for vertical interest. • Low wooden planters containing colorful annuals and low-growing junipers form a permanent parterre bordering the sculptures.

(SWA Group, Landscape Architects, 1999,p.176)	

APPENDIX A:Table 8

DESIGN DETAILS OF ROOFTOP GARDENS
8.0 WATER

<table>
<tr><td>
Fig.1: Pernas International Hotel, Kuala Lumpur, Malaysia.
(Lawrance Halprin and Associates, 1999,p.180)</td><td>• The water feature in the garden is a central fountain constructed of polished and naturally finished stone. The remainder of the water actually consists of river rock, beach stone and gravel, carefully selected for size and placed to create impression of nature.</td></tr>
<tr><td>
Fig.2: Ghirardelli Square, San Francisco.
(Lawrance Halprin and Associates, 1999,p.182)</td><td>• The fountain is one of the key points of interest in the stream as it flows around the entire roof.
• The fountain is all cut and polished granite.
• The largest plaza, designed and used for public events, features a granite sculptured fountain.</td></tr>
<tr><td>
Fig.3: Thoreau Hall, University of California.
(Theodore Osmundson and Associates, 1999,p.185)</td><td>• The fountain basins are of polished dark green terrazzo laid over concrete.
• The principal water feature, small but spectacular, is in perfect scale with the trees that surround it.
• The fountain offers a pleasant visual and aural backdrop for the park.</td></tr>
<tr><td>
Fig.4: 444 South Flower Terrace, Los Angeles.
(Lawrance Halprin and Associates, 1999,p.187)</td><td>• The fountain flows into the pool. From upper fountain, water flows beneath granite slabs that form stepping-stones over it. It then descends via shallow waterfall into a lower pool, from which it is re-circulated back to the pump in the existing structure below and then to fountain.
• Additional water is added to the system only compensate for evaporation. The water effects are achieved minimal addition of weight to the existing roof below.</td></tr>
</table>

APPENDIX B:Table 1

DESIGN ELEMENTS OF GREEN ROOFS Justus Van Effen Complex- The Green Street in the Air (Rotterdam-The Netherlands)			
			
1.0 Planting Variety Courtyard View.(Crosby, 2001, p..13)	2.0 Plant Containers Elevated street provides access to the residential units. (Crosby, 2001, p.43)	3.0 Paving Surfaces The main entrance and front deck of common areas. (Crosby, 2001, p.13)	4.0 Furnishings Elevated street provides social area for residents. (Crosby, 2001, p.43)
			
5.0 Lighting Lighting elements are located along the pathway. (Crosby, 2001, p.47)	6.0 Shelters Shelter elements are located on main entrance.(Crosby, 2001, p.51)	7.0 Sculpture The rough natural stone is used within grass paving. (Crosby, 2001, p.53)	8.0 Water The water elements are not available.
Main Findings	The deck and the elevated street are the main design elements. These architectural aesthetics provide comfort living space and habitat for residents.		

Table 4.1: This table demonstrates that the summary of the design elements which are examined on under the residential building typology.

APPENDIX B:Table 2

DESIGN ELEMENTS OF GREEN ROOFS Hillside Terrace-The Slow City (Tokyo-Japan)			
			
1.0 Planting Variety GreenRoof View.	2.0 Plant Containers Concrete edge containers are located on the entrance piazza.	3.0 Paving Surfaces The main plaza is covered bright-white granite.	4.0 Furnishings Permanent benches are located on edge part of the plaza.
			
5.0 Lighting Medium size lamps are located on along the pedestrian walkway.	6.0 Shelters Cantilevered structure system provides shaded elements.	7.0 Sculpture Planted Courtyard provides social activities for residents.	8.0 Water Concrete made fountain located on the edge part of the piazza.
Main Findings	Green community corridor is the main design element. This architectural aesthetics provides comfort living space and habitat for residents.		

Table 4.2: This table demonstrates that the summary of the design elements which are examined on under the residential building typology.

APPENDIX B:Table 2

APPENDIX B:Table 3

DESIGN ELEMENTS OF GREEN ROOFS Jeanne Hachette Complex-My Terrace-In Front of My House (Paris-France)			
			
1.0 Planting Variety Mature trees, perennials and vegetated walls are the main plantings.	2.0 Plant Containers Concrete containers are located on the edge part of balustrades.	3.0 Paving Surfaces Modular concrete is located within the grass.	4.0 Furnishings Permanent concrete benches are located on along the terraces.
			
5.0 Lighting Light-bulbs are hided on the edge part of the terraces.	6.0 Shelters Mature trees and cantilevered concrete terraces provide shading.	7.0 Sculpture On the top of the building is located on extensive green roof top within abstract sculptures.	8.0 Water
Main Findings	Green terrace is the main design element. This architectural aesthetics provides comfort living space and habitat for residents.		

Table 4.3: This table demonstrates that the summary of the design elements which are examined on under the residential building typology.

APPENDIX B:Table 3

APPENDIX B:Table 4

DESIGN ELEMENTS OF GREEN ROOFS Barbican Complex-An Exquiste Ghetto (London-United Kingdom)			
			
1.0 Planting Variety Perennial and annual flowers and shrubs are located within the grass.	2.0 Plant Containers Wooden made temporary containers and concrete made permanent container are located along the squares.	3.0 Paving Surfaces The interlocking brick lane and concrete are used on the surfaces.	4.0 Furnishings Comfortable chairs, benches and tables are located along the activity plaza.
			
5.0 Lighting Medium size and hided bulbs are located on along the artificial lake.	6.0 Shelters Tensile structures and iron made pavilions are located along the squares.	7.0 Sculpture Plant containers are designed as like a contemporary sculpture.	8.0 Water Fountains are located on semi-circular openings inside the artificial lake.
Main Findings	Connected podium, elevated green street and water are the main design elements. These architectural aesthetics provide comfort living space and habitat for residents.		

APPENDIX B:Table 4

Table 4.5: This table demonstrates that the summary of the design elements which are examined on under the residential building typology.

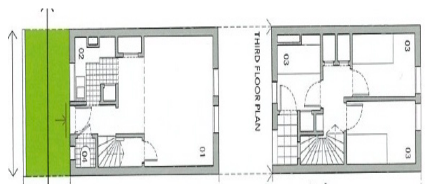
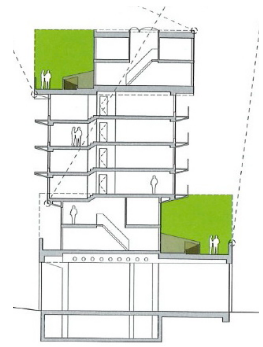
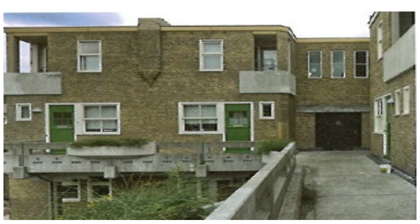
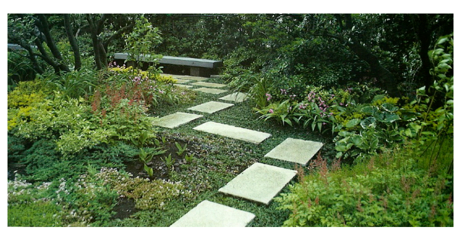
APPENDIX B:Table 5

DESIGN ELEMENTS OF GREEN ROOFS Barbican Complex-An Exquiste Ghetto (London-United Kingdom)			
			
1.0 Planting Variety Mature trees and edge planters are located along the terraces.	2.0 Plant Containers Concrete edge containers are integrated on the balustrades.	3.0 Paving Surfaces Modular concrete paving is covered by along the walkways.	4.0 Furnishings Permanent concrete benches are located on the roof top.
			
5.0 Lighting Ornamented light bulbs are located inside of the iron grids.	6.0 Shelters Columnar pedestrian walkway and mature trees use as a shading element.	7.0 Sculpture Concrete containers are filled in white gravel for using as a sculpture.	8.0 Water The pond within fountain is located at the center part of the courtyard.
Main Findings	Vegetated terrace is the main design element. This architectural aesthetics provides comfort living space and habitat for residents.		

Table 4.4: This table demonstrates that the summary of the design elements which are examined on under the residential building typology.

NDIX C:TABLE 1

Justus Van Effen Complex t: Michiel Brinkman m-Netherlands 22	**INVENTORY FORM OF GREEN ROOF DESGINS ON BUILDING TYP** Type of Building: Residential-Justus Van Effen Complex- The Green Street in t

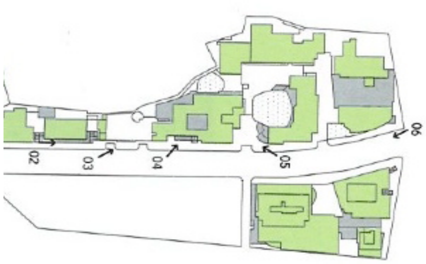
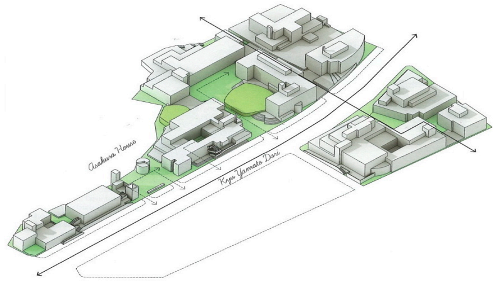
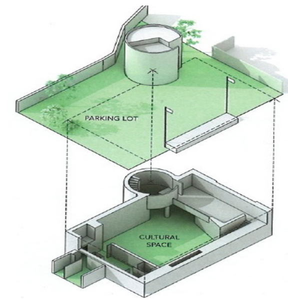
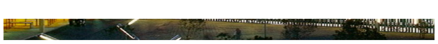
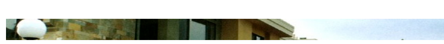
		
	Plan	Section
PICTURES	**PICTURES**	**EXPLANATION**
		• There are medium siz irregular forms with mediu on the roof. • Medium sized plants and sh irregular formed and a coar are exist. • There are some ground co variety of colorful plant tex
		• Containers are located on th balustrades. These rectangular containers are concrete and also located o part of the deck. • The deck is also included green roof container.
		• The main entrance is co interlocking brick. • The ground cover of the plaza at the sides of entrance is grass and granit • The deck is also made by concrete. • The floor covering of pla small concrete tile.
		• There are some tempora elements are located on th deck. • The edge part of the intens roofs are designed as elements. • The balustrades and edge p balconies use as a sitting el

NDIX C:TABLE 1

			• There is no water elements at this building.

dings	It attempted to create a sense of belonging among residents, who were termed in institutions, as they w residents who held a firm belief in benefits of collective living with green vegetated spaces.
ts	The main aim to transfer the freedom and spontaneity of the vegetated street to the elevated street makes th ambiguous element.

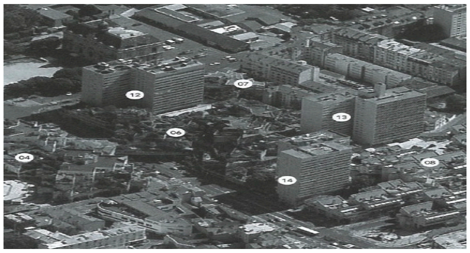
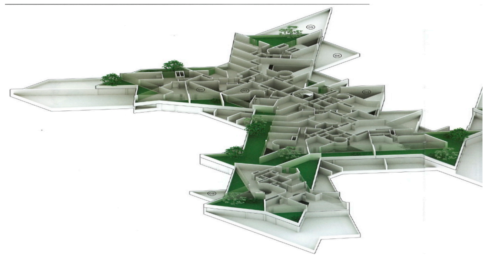
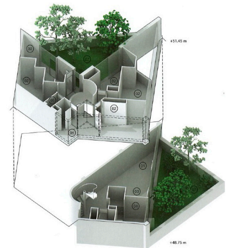
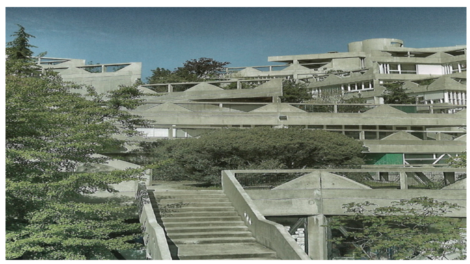
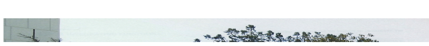
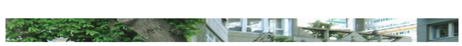
NDIX C:Table 2

Hillside Terrace t: Fumihiko Maki apan 98	**INVENTORY FORM OF GREEN ROOF DESGINS ON BUILDING TYP** Type of Building: Residential- Hillside Terrace-The Slow City	
		
	Plan	Section
PICTURES	**PICTURES**	**EXPLANATION**
		• The trees are irregularly plan point where the pavement pathway is separated the n and pedestrian walk. • Through the concrete conta planted medium size pla irregular form. Shrubs with size, fine and course texture planted.
		• The concrete containers ar generally at the entrance pa building. They are planted wi trees. These containers separation between stre pedestrian.
		• The main paths mostly have 2m and have been covered by paving materials, which oc changes within the grass su the ground. In most of th concrete floor coverings of pattern. • The main entrance plaza is c textured pavement.
		• The concrete balustrades a elevated street are used sittin and also concerned user safety • The slopped concrete surfa paving on rooftop offers ac children. Concrete balustr surrounded through this acti which are designed for a sittin
		• Lighting elements are instal the short wall that borders the

NDIX C:Table 2

dings	The composition is based on more than just hygienist urbanism. It is a fragmentary green urbanism with shifting concept of what individual space is.
ts	This partial way of conceiving green urbanism can be summed up in four concepts; the importance of g design, the standardization of residential modules, the adaptability to change and the adoption of residential

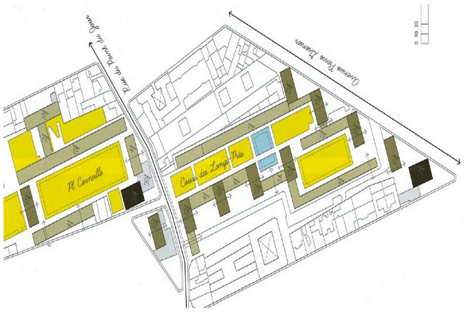
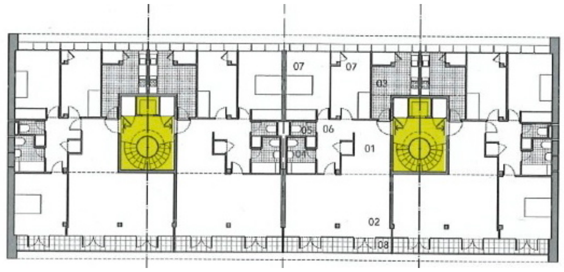
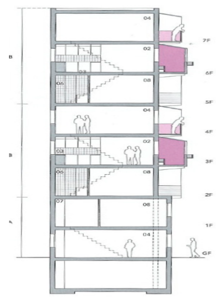
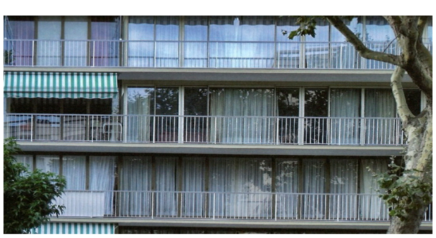
DIX C:Table 3

Jeanne Hachette Complex t: Jean Renaudie nce 75	INVENTORY FORM OF GREEN ROOF DESGINS ON BUILDING TYP Type of Building: Residential- My Terrace, In Front of My House, Over Yours	
		
	Plan	Section
PICTURES	**PICTURES**	**EXPLANATION**
		• The plants are selected acc their ability to facilitate bio grow in the hydroponic m withstand indoor conditic varying levels of lig temperature. • Although a range of plant used, woody tropical species.
		• In the case, one can climb fr level to the terraces on t storey, following an landscaped route. Path galleries, the vertical cores small paths, which meande artificial hill.
		• Asphalt and concrete can be a manner that creates a series that allow water and air travel • Such porous pavements are e mitigating storm water runc porous asphalt is more ec than porous concrete, both have been successfully emp the field.
		• The vegetated terraces and use as a street furnishing for Most of the street benches ar concrete and located on a terraces. • The edge part of the plant c also uses as a sitting element.
		• Lighting elements are fixec the terraces. Generally, they

NDIX C:Table 3

dings	As this study of the Paris residential complex shows, the key concepts focused on the cons management and social aspects of multifamily housing to support the appraisal of a building's dura
ts	The key concepts are crucial for maintaining the quality and durability of investment prospects.

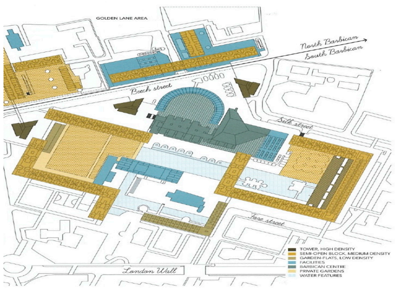
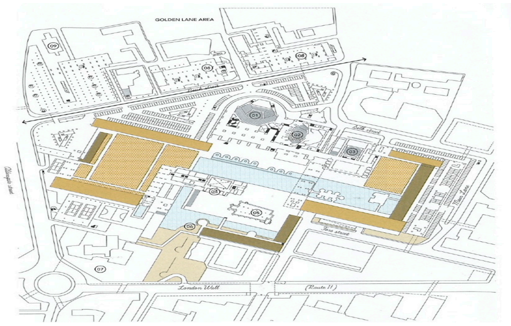
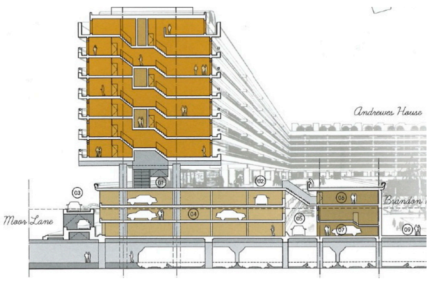
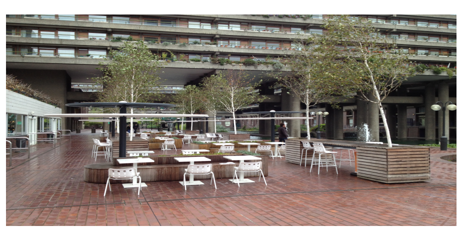
ꞮDIX C:Table 4

Residence Du Point Du Jour t: Fernard Pouillon ınce 53	**INVENTORY FORM OF GREEN ROOF DESGINS ON BUILDING TYPI** Type of Building: Residential- Residence Du Point Du Jour-Cristal Liquide	
		
	Plan	Section
PICTURES	**PICTURES**	**EXPLANATION**
		• There are several type of t as; big in irregular fori medium size in fine text Towards the building diversification; medium columnar palm trees are plai tall and medium size tr medium texture have been p
		• There are a variety of available, for example at garden is used intensi containers for mature trees Terraces and balconie rectangular concrete made containers.
		• The paths are various sizes heavily used area. All covered by matt tile in grey • The plaza is covered by natu • The ground cover is mat modular pure brut-concrete slippery in this space.
		• There are no perma contemporary street available. The terraces and are surrounded by metal or balustrade within containers.
		• Lighting elements height

NDIX C:Table 4

dings	Within these monumental voids, green pedestrian walkway is a distant murmur and glimpses of the stre through horizontal vegetated surfaces.
ts	In the midst of this peace and green tranquility, it is the complex, which reveals itself and speaks directly green roof design.

NDIX C:Table 5

Barbican Complex t: Peter Chamberlin United Kingdom 33	**INVENTORY FORM OF GREEN ROOF DESGINS ON BUILDING TYPI** Type of Building: Residential- Barbican Complex-An Exquiste Ghetto	
		
	Plan	Section
PICTURES	**PICTURES**	**EXPLANATION**
		• Rounded medium size t planted in the middle of p walkway. Columnar types of located on along the paveme complex. Columnar trees ar size and have fine texture.
		• There are a variety of conta located on through the com example concrete made edge located on the semi-circular s Also wooden made modular t containers are located on a main plaza.
		• The ground surface is co interlocking red brick mate edge surfaces of the contai made of red-brick. • The bridges which are loca the residential units are co pure brut-concrete material.
		• The concrete made edge su used as a sitting element th residential blocks. • The temporary metallic elements are located along piazza.
		• The lighting elements r

NDIX C:Table 5

ıdings	In the case of the Barbican, the reason for its eventual success was the determination of those who s believed it was possible to create the complex city with a clear focus on the wellbeing of its residents.
ıts	Architectural requirements and sustainable policies in appeal an experiment in social housing form at the fu