Climate Change Adaptation:
Retrofitting Communities

engleback & jackson

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This guide summarises work for a study carried out in 2012-13, led by the authors and their study team for a retrofitting of Dalby Square, Margate, Kent commissioned Thanet District Council and funded by the Technology Strategy Board.

The Retrofitting Study Team for Dalby Square, Margate included : Daedalus Environmental, Studio Engleback, Radius Regeneration, WT Partnership and SDA.

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“Climate Change is one of the greatest challenges facing the world’s environment, society, and economy today. Its impacts can already be seen across the world and the UK will not be immune”

Foreword to *‘Adapting to climate change: a checklist for development’* 11.2005
Graham Tubb - Chairman of the South East Climate Change Partnership)

Contents

"Adaptation helps ensure that our urban environments are more robust in the face of inevitable climate change, but it offers other opportunities as well. By building adaptive capacity and delivering sound adaptation solutions we can also make cities more attractive, with better quality of life."

Delivering adaptation action - Climate change adaptation by design (TCPA 2007)

Introduction

Greenhouse gases help to retain solar heat on Earth, without them we would be a very cold planet, but they comprise only a tiny fraction of the atmosphere. The most abundant greenhouse gas (ghg) is carbon dioxide at 0.038%, other greenhouse gases are present in even smaller concentrations include methane, nitrous oxides, and man made gases used in refrigeration. In less than 300 years, human industry and land use change has placed the same amount of greenhouses gases again into the atmosphere as has occurred over the past 100 000 years.

Human produced global carbon emissions levels have stepped up, and are currently mirroring the worst case scenario projections by the United Nations Intergovernmental Panel on Climate Change. The disruption to the global climate is already resulting in changed weather patterns and more extreme weather events that will increasingly affect the global economy and our everyday lives.

It seems that a real global agreement on emissions cuts is a long way off, so we must act without it. Adapting to future climate change requires a different approach to design, planning and management of our urban environment at all scales of intervention. We explored aspects of this in Margate, because the majority of the existing homes will still be in use in 2050, and they will need retrofitting. We also need to upgrade the *green infrastructure* in an around towns that delivers a range of *green services* that support the urban environment and make it more resilient to change.

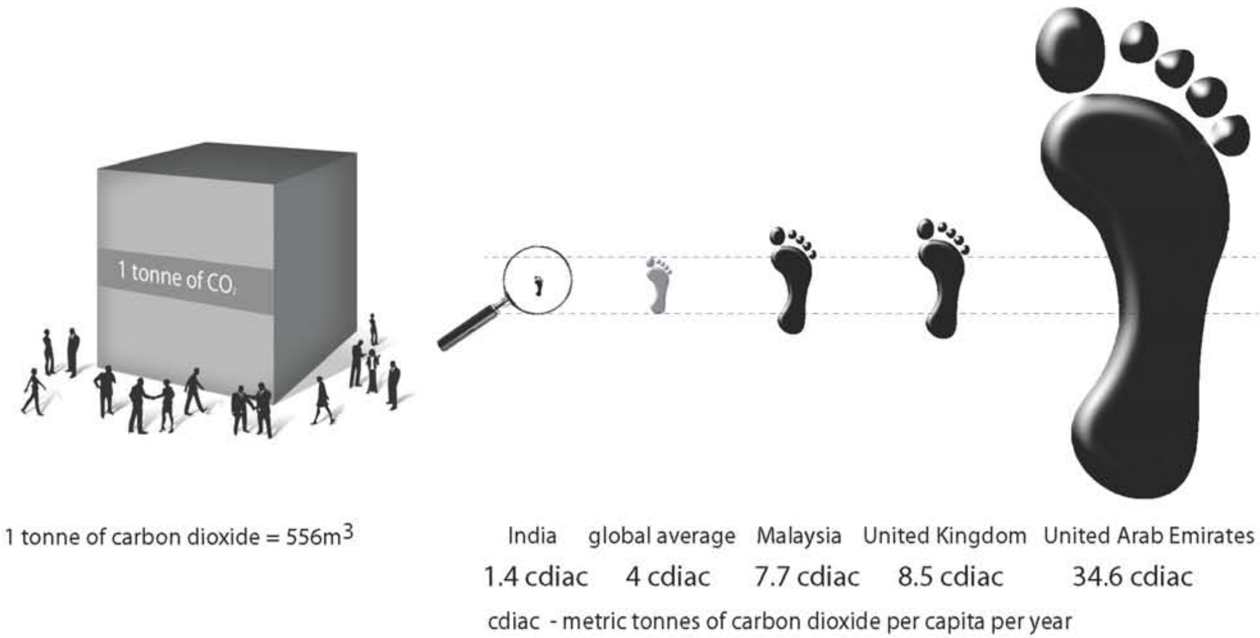
Atmospheric carbon levels change over time, and have been much higher in the distant past, when the world was much hotter as a consequence. Carbon is a component of Sugars, Proteins, Starches, and Cellulose; it is a building block of life. Using the Sun's energy, plants capture carbon in the atmosphere to make these molecules. Coal and oil was made from plants that captured atmospheric carbon over hundreds of thousands of years, and in so doing helped to cool the planet.

Carbon is also absorbed by plankton and shellfish that form limestone and chalk - the raw material for making cement and concrete. Carbon is also present in soils as humus, and in forests as wood. The process of making cement releases carbon dioxide, as does ploughing virgin soils or cutting down forests to make farm land. Currently an area of forest over twice the size of the size of Belgium, Holland, and Luxemburg is felled every year mainly to grow energy crops, or to raise cattle.

There are about 1.3 billion cattle in the world. When cattle eat grass they produce methane, they each burp or pass wind at a rate of 70-140 kilograms per year. Methane is a greenhouse gas that is 23 times more potent than carbon dioxide. It is also present in the frozen bogs of the Tundra, so when these melt it is also given off. The Tundra of the Arctic is warming much faster than the rest of the world.

Modern fertilisers contain nitrogen which are needed to increase crop yields to feed over 7 billion people, but not all of the fertiliser applied is used by the crops, some is washed away, and some is used by bacteria in the soil producing nitrous oxide. This is a green house gas 300 times more potent than carbon dioxide. About 10% of the United Kingdom's carbon emissions comes from farming.

Most solar heat falls on the equatorial zone, and it is distributed through the world by ocean currents. All ocean currents are linked, flowing around all the continents. A circuit may take 30 or more years, so past warming will affect the climate for the next three to four decades. This is why we need to adapt to expected changes in the climate whilst at the same time limiting future changes. So that we are clear, **climate** is taken from at least 30 years of average **weather** - as there may be year



graphic: studio engleback

year-on-year changes in weather. Looking at climate rather than just weather gives us a broader perspective of trends.

Our current lifestyle is inextricably linked with carbon dioxide emissions either at home or abroad. The Climate Change Act (2008) set in train legally binding five yearly carbon reduction budgets to transform the United Kingdom into a Low Carbon Economy. The aim is a minimum 80% cut in UK Carbon Emissions by 2050 compared to 1990. It will be difficult make such a huge change in our life style, but we must adapt to a new way of living.

This can only be achieved by collective action, which includes a multitude of relatively small actions, but especially changes in currently entrenched habits.

Global temperatures have risen an average of 0.6˚c over the past 100 years, but are forecast to rise between 2-4˚c over the coming century. The warming is already disrupting weather patterns, which affect energy use, harvests, water availability, plus human and ecological health. These forces will profoundly affect the global economy and the way we live.

In the last ten years we have experienced the hottest and coldest of summers on record, the wettest and driest winters and the warmest and coldest of winters. In sum we have experienced a full range of climatic conditions that highlights the issue of climate disruption, the range of scenarios for which we already need adaptation measures, and the imperative for simultaneous mitigation of the causes.

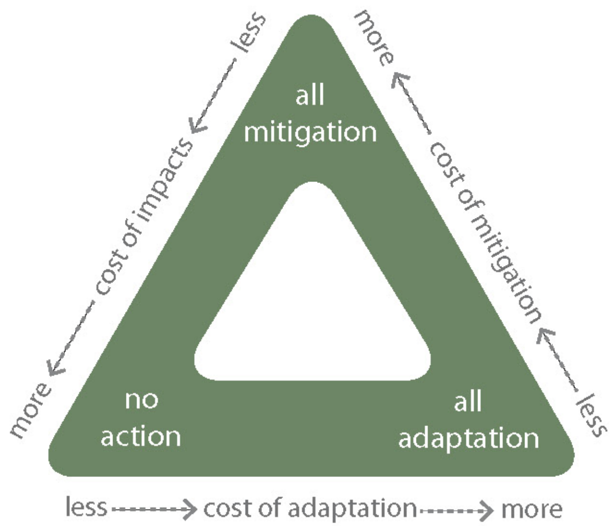
The diagram above illustrates the volume occupied by one tonne of carbon dioxide. in the United Kingdom we each emit about 8.5 tonnes per year - that is similar to the volume of a terrace of houses. We are not the largest emitters of carbon dioxide per capita in the world, but we are a numerous Nation so it adds up! Global trading blurs these national statistics, so our foot print is really much larger. Adaptation of towns and cites for future climate change can be achieved by retrofitting existing areas or be wholesale redevelopment. The Building industry in the United Kingdom accounts for about half of all our carbon emissions, so choices we make for materials has an impact on our carbon emissions, and these need to shrink by 80% over the next 37 years.

We need both adaptation to, and mitigation of, future climate change. These are two sides of the same coin, and in an era of economic austerity it is vital that we invest wisely in measures that will improve our collective future. Here lies the potential for new manufacturing, fitting and servicing opportunities that can help to restart our local economies.

The incidence of heavy storm events has increased around the globe, and changes appear to be accelerating because our carbon based behaviour is slow to change. The concern of many scientists is that a 'tipping point' in levels of atmospheric carbon levels may be reached within a few decades and that could trigger *catastrophic* climate change.

Because in the United Kingdom about 90% of us live in Urban Areas we need to adapt towns, the buildings and spaces in them, both to deal with the challenges of a changed climate, and to offer the flexibility to live in a way that can adapt to the wider global changes that will occur due to a frightening mix of climate change, resource depletion, and quite possibly an altered global economic framework.

Past carbon emissions have guaranteed change in the next 30-40 years, and how we behave from now on will effect the time beyond that. We have already witnessed how ignoring known problems in the banking system led to the Global financial crash of 2008. Four years later we are still suffering from the fall out of that crisis, and its effects are far from over in the West.



source: Climate change 2007 - Impacts, adaptation and vulnerability
graphic: studio engleback

In his report on **The Economics of Climate Change**, Nicholas Stern considered that an investment of about 1% of the global GDP each year may help us all avoid the worst impacts of climate change, but not acting would be the equivalent of losing *"at least 5% of global GDP each year, now and forever".* Furthermore he predicted that if a wider range of climate change risks and impacts are not taken into account now, the estimates of damage could rise to more than a fifth of the global GDP. Quite simply, that would be a trigger for the scale of economic and social problems that caused the great wars and depressions of the early 20th century. It is reminiscent of the adage - *a stitch in time saves nine.*

By 2009 prior to the Climate Summit in Copenhagen, Stern had revised his thinking, estimating the cost to be 30% of GDP on the basis of new scientific evidence showing that warming was happening faster, and that it was worse than he had thought. This provides the imperative both to adapt to, and to mitigate the causes of, future climate change now.

Spending too much on mitigation of future climate change without also making adaptations to change that is already happening is a risk. Finding the middle ground for action will vary according to circumstance and location.

We have become familiar with the term 'Global Warming', but this can obscure the real problem, which is actually about Climate Disruption. The average rise in global temperatures is just that - an average - with some regions, such as the Arctic, warming much faster than other areas on Earth. The exaggeration in extreme weather events seems to be increasing such as the

“There is still time to avoid the worst impacts of climate change if strong collective action starts now”

The Stern Report: The Economics of Climate Change
Reported to the Prime Minister and Chancellor in Autumn 2006
Published January 2007

2010 flooding in Pakistan that saw about 20% of the land area inundated, and area the size of France and Germany flooded in Australia during 2010/11, 20 000 km^2 of farmland destroyed in the 2011 floods in Thailand, or our own wet summer of 2012.

A warmer atmosphere carries more water vapour - there is 5% more in the atmosphere than 100 years ago - and this leads to heavier rain events. Those floods in Thailand had economic consequences that went far beyond their boundaries, because most of the computer hard discs manufactured in the world are made there, and the knock-on effects for the computer industry in Japan, for example, are still being felt today.

Just as major floods in one country have affected the lives of people not directly experiencing them, the devastating droughts in Western Australia, the USA since 2010, and the Russian heat wave of 2010 had other consequences. Food prices spiked as a consequence of reduced harvests, and this points to a wider vulnerability we are all exposed to in a crowded world.

The European heat wave in 2003, which may be taken as an example of things to come, saw tens of thousands of excess deaths in a few days - mostly in France where there is little greenery in cities, but also the UK. Southern cities tend to have narrower streets presenting less masonry that might be heated and then re-radiate heat, whereas northern cities have wider streets. So changing the nature of our urban external environment may be a key adaptation measure as the century progresses. Here there is a direct link between sustainable urban drainage and urban thermal regulation using planting.

Climate change in the UK, especially in the East and South East, is forecast to lead to drier soils in summer and autumn. Not only are drier soils more difficult to hydrate when it does rain, with heavy rain running off it as it might a paved surface, but without access to water, planting cannot deliver cooling, and a water stressed plant is more likely to become a victim of disease.

A mature tree can deliver the cooling equivalent to five large air conditioning units running for 19 hours, but needs about 300-450 litres per day to do so, if this is not available in the soil, in the first instance the tree delivers less cooling, and if the drought it prolonged it may die. Investment in soils, making urban surfaces more porous will be a key adaptation measure for dealing with the urban tree resource, whilst contributing to a reduction in the quantum of urban surface water runoff that causes flooding and point loading of pollutants. Again this is an example of the diffusion effect of local interventions on the wider environment.

We tend to think of natural systems changing very slowly, but actually this is not always the case. Processes my be slow but can lead to a rapid change. The idea of a 'tipping point' was mentioned in the introduction to this booklet - this may be caused by a small action that leads to a significant event, like *the last straw that broke the camel's back*. Given the complexity of the natural systems

Increased incidence of heavy rain events

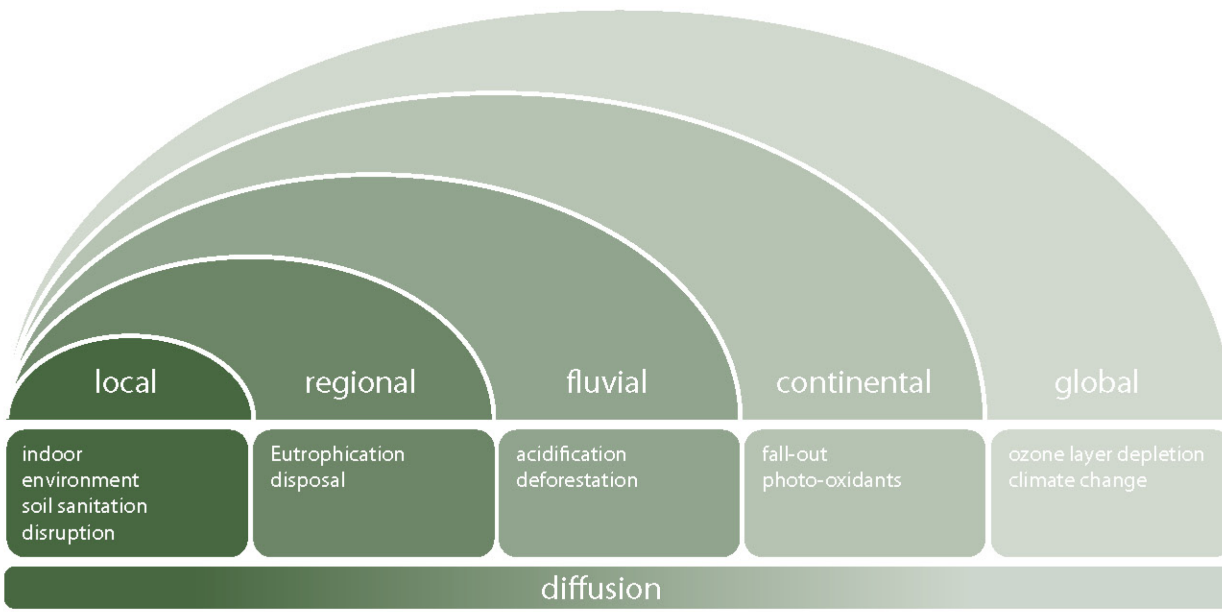
Increased incidence of heatwaves

on Earth, each interacting or impinging on the other, a better analogy would be the domino effect, a series of tipping points, one leading to the next. This is an important concept because we need to view our investment in adaptation measures within a wider context to really appreciate their value.

For example, few will forget the devastating famine in Ethiopia in the 1980s, but the Ethiopian famine that occurred in 2011 may be the first that can be linked to global climate change. The US Geological Survey found that sea surface temperatures in the west central Pacific and Indian Oceans have risen faster than other areas causing more rain to fall over oceans so that drier air rises over East Africa. Although the Ethiopians have planted trees to retain water on mountain slopes since 1980, a local degradation of their own environment that had contributed to that earlier famine, the latest catastrophe was framed by our excessive use of energy derived from coal and oil.

Similarly the wet summer of 2012 in the UK coincided with drought in Russia and in the USA. Rapid warming in the Arctic is thought to have reduced the temperature difference between the equatorial and polar regions which in turn affects the fast winds in the upper atmosphere winds known as the *jet stream*, which in turn influence the progression of weather systems across the North Atlantic that affect us. The jet stream can move north or south and the consequences are either pulling very cold air from the east or north, or rain bearing weather systems from the southwest.

At a hemispherical scale the jet stream is affected by high or low pressure predominating over Russia or North America, it can get stuck in a groove, so to speak and deliver prolonged periods of wet, cold or hot weather to us depending on if the winds are being pulled from the Atlantic, Siberia or Southern Europe. These are examples of how the Earth systems are



source: carley and christie (1992: 199, Fig. 9.2)
graphic: studio engleback

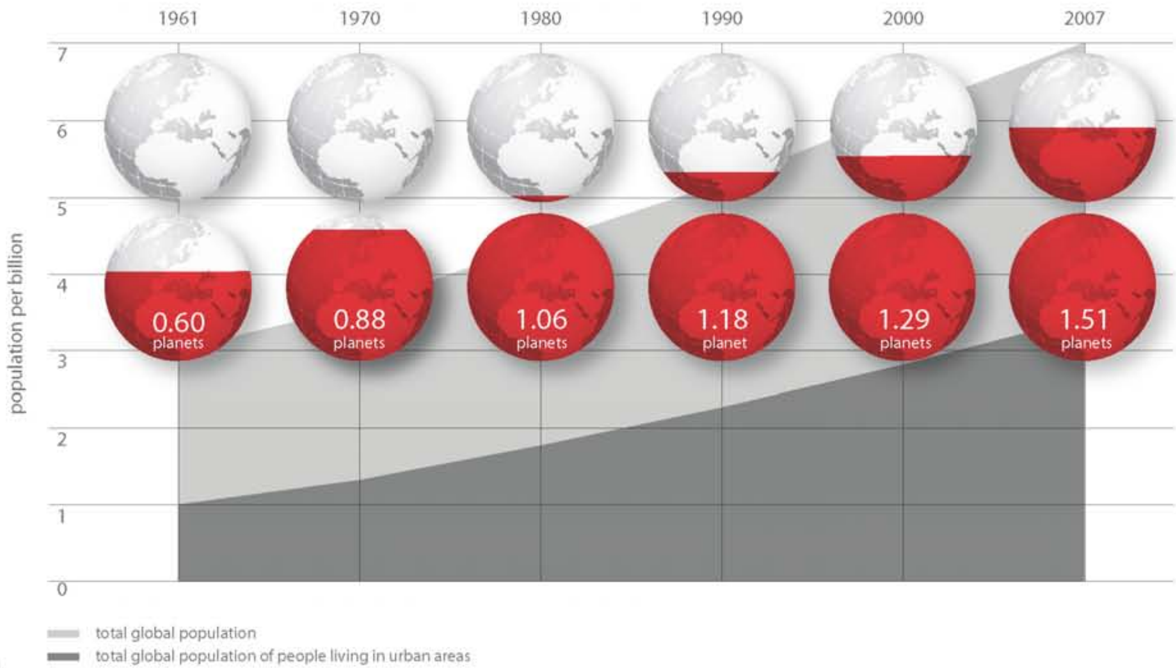
The diffusion diagram illustrates how levels of intervention are interconnected and can impact upon each other inter connected, and how a localised event can have wider effects. We tend to forget how closely related our economic systems are to natural systems, but we feel the effects of changes elsewhere in terms of higher prices for commodities. So the key message here is that whilst climate change will affect our weather, there are wider ramifications, and we need to take a holistic view in how we adapt to them. This means placing an increased importance on the green infrastructure that is an integral part of our urban Life-style.

The diffusion diagram below illustrates the knock on, cumulative, effects of events at local level on the wider global system. Although the scale of the problems we face is enormous we can all make a difference, because the collective force of many small actions adds up to something meaningful. There is a cascade effect of numerous actions at the micro scale that if carried out on a large enough scale can effect the macro scale.

Retrofitting our homes and cities to address the future climate change can take many forms. The key thing is to grasp the array of possibilities, and to see that ultimately we have to change our own behaviour. If we introduce the potential for flexibility, rather than cutting down our options, we are more likely to succeed without wasting time or our investment.

The scale of retrofitting required is vast. In the United Kingdom there are about twenty two and half million homes. Collectively, these homes contribute in the order of 27% of the national carbon emissions.

As the first industrialised and urbanised nation, the UK has a legacy of inefficient dwellings, that ranks amongst the highest in Europe. Around 85% of these buildings are likely to still be standing in 2050 when overall national carbon emissions are supposed to have been cut by at least 80% over 1990 levels. With a changing energy future as well as our legally binding commitment to reduce carbon emissions, this is a huge challenge and also a great opportunity to create a range of jobs. Investment in reducing our energy use far into the future by investment now at macro, meso and micro levels of intervention will make out country more resilient in a changing world.



Planets consumed against global population & population in urban areas

notes:
planets consumed is a calculation of global average ecological footprint to global average biocapacity ratio

source: an urban approach to climate-sensitive design - strategies for the tropics by m. rohinton emmanuel
graphics: studio engleback

"If humanity wishes to preserve a planet similar to that on which civilization developed and to which life on Earth is adapted, paleoclimate evidence and ongoing climate change suggest that CO_2 will need to be reduced from its current 385 ppm to at most 350 ppm."

NASA scientist Jim Hansen 2011

N.B. on May 9th 2013 we exceed 400ppm CO_2 in the atmosphere for the first time in several millions of years

Buildings will face a number of different challenges in the coming decades as the changes to the climate emerge. These can broadly be split into four separate categories that could be considered for a whole house retrofit scheme: overheating, the ability to keep warm, water availability and, management and risk to the building structure. This section of the guide explains these risks in more detail, and provides some solutions that could be considered in the design process.

View from 30 Dalby Square across the garden, 2012

Project Profile

The project is located in the district of Thanet, at the most easterly end of the county of Kent. The project has been developed with the aim of regenerating areas of both Margate and Cliftonville which have some of the highest levels of deprivation in the region. It involves the purchase and refurbishment of a number of large properties to help facilitate the regeneration of the area by (amongst other projects):

- The reinstatement of hotels to provide high quality tourist accommodation for the area.
- The conversion of HMOs and other low grade residential accommodation, retrofitting them to a far higher standard, and then creating a management structure using the social housing model.

The properties themselves are of consistently exceptional architectural merit, typical of coastal towns developed from the Victorian era and into the Edwardian period. They are typically very large, 4-5 storey terraced properties: such properties can be found repeatedly in Brighton, Hove, Hastings, St Leonards, Broadstairs and many other historic seaside resorts. The properties that form part of the project are spread across 40 different streets, and a total of 1,600 different freehold properties.

The concept of the housing renewal area is predicated on the refurbishment of existing buildings, not redevelopment. The area is one of high historic value and the project provides an exemplar of the sustainable re-use of heritage structures. It provides the ideal opportunity to develop a strategy that increases the resilience of a set of properties that are highly typical of coastal seaside resorts. The ability to scale up the approach, replicating it into other areas, is considerable. In addition, many seaside towns are now characterised by high levels of deprivation and social exclusion, and finding good solutions for the built environment, providing sustainable and good standards of accommodation that are habitable in the long term is an important part of alleviating these issues.
Whilst the wider project, of which this study is a part, covers large areas of Cliftonville, the D4FC2 project had five different initial areas of focus, as follows:

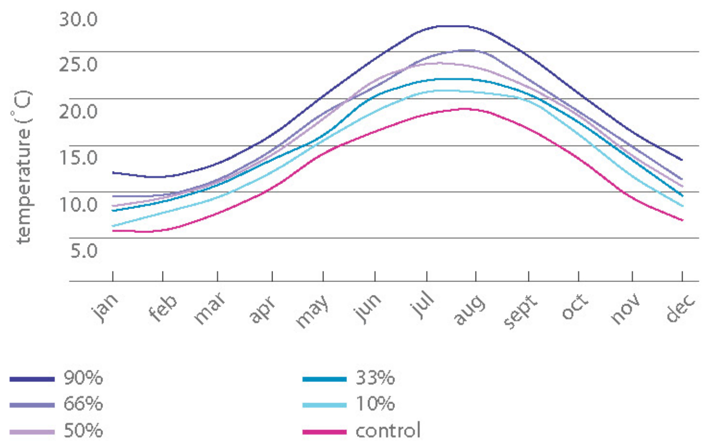
- 30 Dalby Square Option 1 – an empty HMO property to be converted into a single, multi-generational dwelling (see below for more information)
- 30 Dalby Square Option 2 – an empty HMO property to be converted into a boutique, 3 bedroom hotel
- 31 Dalby Square – an occupied, single dwelling property to be improved
- 1 Dalby Square – a similar dwelling to 31, on the opposite site of the square used as a basis for assessing the impact of orientation on climate change issues
- Dalby Square open space – the area between the houses currently used for parking and limited recreation. This will be used to establish the principles guiding the adaptation of open spaces to climate change impacts

Overheating : The Risk

Over the next 70 years we expect the climate to alter so that warmer summer weather is more prevalent. This may not be a smooth trajectory along the way, and after a very warm decade for the mid 1990s to the mid noughties we have experienced exaggerated weather conditions in summer and winter that are likely to prevail for at least a decade due to the way the jet stream winds in the high atmosphere affect weather systems passing over our country. The reason for these shifts is being investigated at present by the Met Office and others.

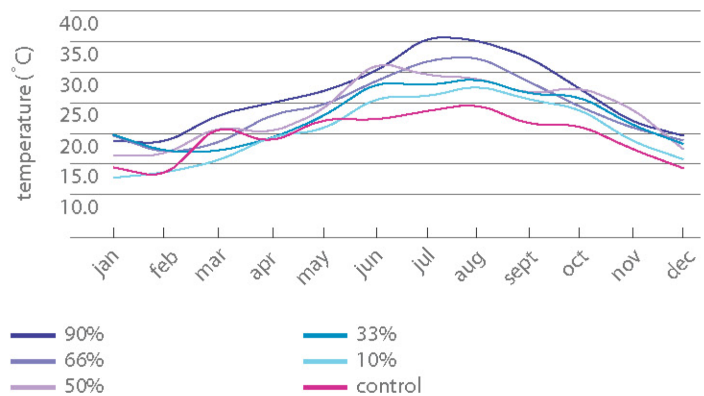
Some reports point to the rapid heating of the Arctic due to anthropological global warming and an altered differential between Equatorial and Arctic average temperatures as being a driver for these changes. In the short term we may expect cooler, wetter summers, but overall, however, the UK Climate Impact Programme still expects our climate to be warmer, and summers to be drier, in the decades ahead.

The following diagrams derived from the Prometheus weather data predictions show the changes in climate that we believe will cause significant risks to the habitability of buildings in 2080. The first of these shows the average daytime (8am-8pm) temperature for each month under the different confidence intervals provided by the data.



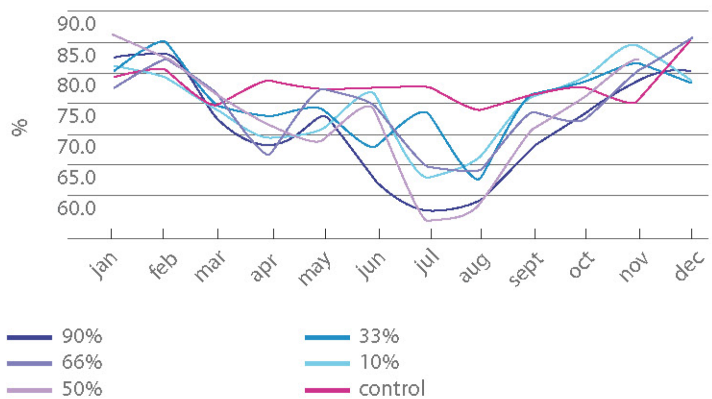
source: exeter university
graphics: studio engleback

Margate 2080 forecast average daily (8am-8pm) bulb temperature ˚C



source: exeter university
graphics: studio engleback

Margate 2080 forecast maximum temperatures ˚C



source: exeter university
graphics: studio engleback

Margate 2080 forecast relative humidity (%)

Under the 90% confidence interval, the average daily temperature rises by about 9°C in July and August. The lowest monthly increase is about 5°C in March. This is a phenomenal increase, and demonstrates that the risk of overheating is significant. Even taking the 50% (mid range) confidence interval data set results in temperature increases of between 2 and 5°C.

What is immediately clear from these diagrams is that the risk of overheating of spaces is significant in the long term, and that this should be a key focus of any climate adaptation strategy in this region. Compounding the issues of increased temperature are large drops in relative humidity, creating a much drier environment.

Adaptation to future climate change there requires a long-term approach to keeping cool, but a shorter term appreciation that the UK may well experience predominantly cooler weather. In both scenarios, if conventional carbon emissions are to be reduced in line with the Climate Change Act (2008) Carbon Budgets which are in place up to 2028 and have a goal of a minimum 80% reduction in carbon emissions over 2990 levels by 2050, it is essential to consider passive and low energy systems, and those that have an inherently low embodied carbon in their manufacture.

Overheating: The Solutions

Shading Options

The most obvious solution for preventing overheating is to examine physical shading options. These can include internal and external blinds, brise-soleil, overhangs, louvers, etc. It is most likely, however, that options around internal and external blinds are the ones most likely to be take forward as a result of the cost and unobtrusive visual appearance.

In terms of modeling the effects of the blinds one has to assume a certain pattern of use (usage profile) within any modeling software: it is difficult to model behaviour within the software other than based on specific criteria, so in the case of the blinds, this has been based on temperature. That is to say, once the temperature of the room exceeds a certain maximum, the blinds are employed within the model.

The effectiveness of the blinds would in practice be heavily dependent on the ability of the resident to use them in the right way – and this would depend on both their knowledge and on their occupancy of the building.

Roof light / Automatic Opening Vents

Many properties of this type have roof lights above the stairwells that provide natural daylight into the central stair core. These lights are essential given the lack of daylight into these spaces. However, there is the potential to develop these roof lights into a more multifunctional unit – converting the current, fixed unit into an automatic opening vent controlled on the basis of temperature.

The aim of converting this roof light to a glazed AOV would be to maintain the level of light into the space, but also provide greater opportunities for natural ventilation of the space. This could also include some level of night time purging to maintain a more comfortable space.

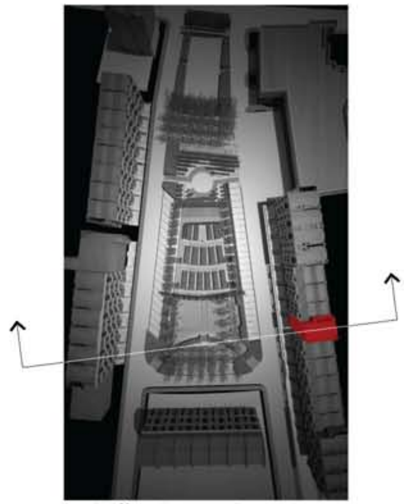
The diagram opposite shows how the system could work, utilising the benefits of natural ventilation bringing in cooler air from the outside and expelling the hot, stale air through the roof vent. The stack effect helps to reinforce this movement up through the central stair core and results in a more effective means of naturally ventilating the internal space. The result is an improvement in air quality, levels of comfort and (if used at night time) cooling capability.

The system would be controlled on the basis of air temperature internally, automatically opening once temperature exceeded a certain level. For the purposes of modeling we assumed this to be 28°C.

To work most effectively of course, residents would need to 'manage' the system – thus windows and doors would need to be opened to generate the air flows through the building. This solution would also only be practicable in the 3G housing scenario – applying it in hotel situations is more problematic – bedroom doors cannot simply be left open. However, it was also felt that in practical terms, occupants may not be able to do this as effectively as they should, and therefore this form of natural ventilation/cooling should be backed up with additional capacity, hence the development of the chimney based solution, described below.

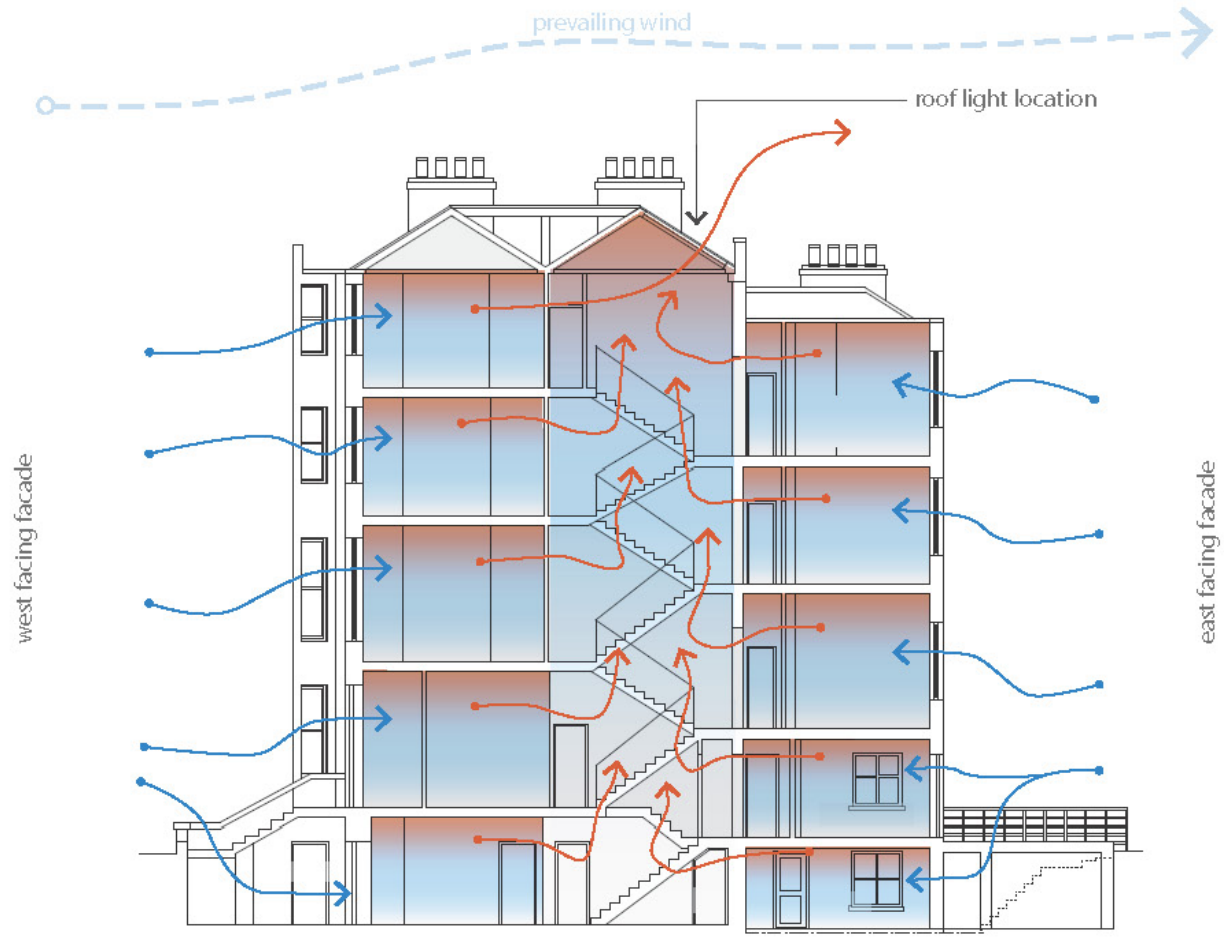
Following discussions with the Building Control department, it also became clear that this system should be used as a smoke vent. The recommendation was that a sprinkler system would need to be installed to comply with Fire Regulations under the new 3G scenario. By enabling the use of the roof light as a smoke ventilation unit, controllable at ground floor level (for the Fire Service, if necessary), then there would be a dual advantage to this design approach.

Given the preponderance of roof lights in residential scenarios of this type, this offers a real means of creating a more comfortable environment in a changing climate.



30 Dalby Square Location and Section Plan

View of existing roof light



Section through 30 Dalby Square: edge in - centre out passive stack system

Graphic: SDA elaborated by studio engleback

Re-use of Existing Chimneys

Buildings of this type were built with chimneys and fireplaces in many of the main rooms of the building. Although quite often found to be boarded up, the physical infrastructure of the chimneys quite often remains. By re-opening these fireplaces, complementary ventilation solutions to the roof light / AOV option can be developed. The issue is to ensure that this ventilation can be controlled in the future. Open fire places have traditionally been source locations for unwanted/uncontrolled ventilation, and the design process has therefore focused on a means of being able to use these fireplaces/chimneys when needed but being able to manually secure them when not in use.

Solar Glass

Solar glass is used to help minimise solar heat gain by rejecting the absorption of solar radiation. It helps to balance the need for high levels of natural daylight with the associated downside of overheating. The product we have recommended for this site is Pilkington Solar-E™ solar glass – an on-line coated, pyrolitic glass. It has both low emissivity – making it more energy efficient, as well as providing good levels of solar control. The u-value for the glass is 1.1W/m2K.

For development proposals which may include large areas of glazed construction, the implementation of higher quality, solar glass would be required to help combat the overheating issue, although this would result in higher initial costs.

Nevertheless, the use of solar glass in replacement glazing still makes sense. The glazing proposed would also be argon filled and also has a better u-value, and thus contributes to better thermal performance and the ability of the dwellings to Keep Warm. As can be seen further on in the cost benefit analysis section, the extra over cost of replacing with solar glass rather than standard glazing is insignificant – and therefore makes perfect sense when considering the longer term benefits.

Replacing glazing is however a high cost solution, especially given the large amount of glazing on the building.

Lighting

We are also proposing that the lighting within the building is converted to LEDs instead of standard fittings. Whilst the use of CFLs is an option, the use of LEDs has the dual benefit of reducing running costs whilst also reducing the heat gains resulting from use of inefficient lighting.

We have been able to assess the running costs of this measure against the alternatives, and the outcome is included in the results section below. In lieu of a full lighting design being carried out, we have initially simply modelled the buildings with different lighting scenarios.

Shading – internal blinds

Advantages and Opportunities

This is a low cost measure, which is simple to install and to replace. There is a wide variety of choice and reflective options, and plenty of interior design opportunities. It is possible to have senor operated automatic control to assist with internal climate management, and this type of fitting could be provided by local suppliers.

Design Issues and Challenges

The problem with venetian blinds is that they with not prevent solar heat from entering the space and so only have a limited effect on thermal comfort. Choice of materials is key. Most blinds are made from aluminium that can present a shiny surface to reflect heat, timber blinds are currently popular and can provide an attractive quality of light entering the room. Natural wood has a lower embodied energy profile, but will not reflect heat as well as lacquered wood or metal blinds.

Venetian blinds

Shading

Advantages and Opportunities

External brise-soleil and shutters are common further south in Europe. In the UK and even in Dalby Square in earlier times, canvas awnings have been traditional measures, once commonly seen on High Street shops. On modern buildings external venetian blinds are sometimes used and these may work better than a shelf like 'brise soleil' on Victorian buildings. In general these measures have a relatively long life with low maintenance, and there are a variety of design options. Importantly, they are efficient at reducing overheating risk.

Design Issues and Challenges

Consideration needs to be given to planning regulations and the impact of shutters, awnings and brise soleil (where applicable in conservation areas). Fixing requires consideration of external structure and of window reveals.

Mechanical Ventilation & Heat Recovery Systems

Advantages and Opportunities

These systems maintain air quality and can be controlled automatically. These could be fitted by local suppliers and could be considered in areas where external air pollution is a problem

Design Issues and Challenges

There needs to be high installation quality to ensure proper functionality, and future maintenance requirements need consideration. If not properly maintained, they could be a drain on energy. Generally they are difficult to install in an occupied house due to the need for ducting, and after installation, the air tightness of property needs to be high to ensure functionality
There is little, or no benefit to climate scenarios in 2080 as cooling is not provided.

Solar Glazing

Advantages and Opportunities

This is a relatively low cost measure in terms of additional cost above standard glazing replacement, and is fairly simple to replace. There would be some reduction of glare and heat gain.

Design Issues and Challenges

In energy reduction terms, the overall impact of this measure is not significant.

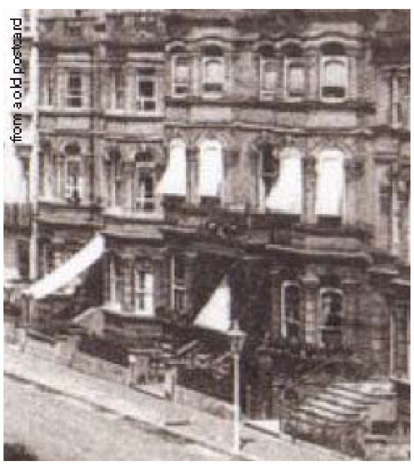
LED Lighting

Advantages and Opportunities

Another relatively low cost measure that is simple to install.

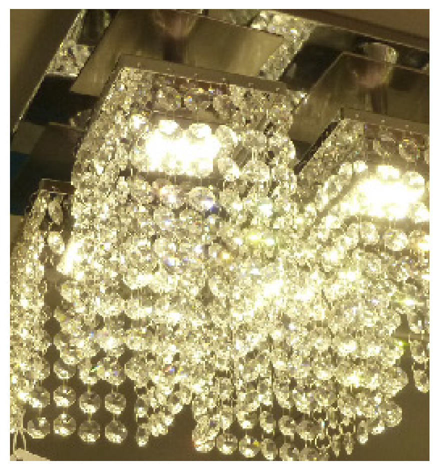
Design Issues and Challenges

This is currently rare in domestic environments, so requires some education, although this is catching on fast. Proper lighting design is needed to get correct lux levels. Worries over the harsh light quality are fading as new products come to market with a warmer light quality.



Canvas awnings in Dalby Square c.1890

HeatSava bathroom vent heat recovery system



LED Chandalier

The Risk

Quite often when considering older buildings up to around 150 years old specifically with solid walled properties in various states of repair, they are often found to be rather leaky structures. This means currently they are very difficult to heat cost effectively. Whilst a warmer climate will mitigate this challenge, there will remain a definite need to ensure that the buildings are well insulated and draught proofed especially given:

- The prevailing breezes, especially in coastal areas, cause pressure differences within buildings creating draughts

- Anticipated rises in energy prices and potential shortages of fossil fuels

- The fact there will still be cold periods when heating will still be required

The Solutions

The need to address thermal performance is also driven by Building Regulations for retrofitted properties – minimum standards apply to the performance of the structure once retrofit works are undertaken.

The basic design approach here, has been to insulate the buildings as far as reasonably possible. The measures introduced into this strategy are as follows:

- Internal insulation
- External insulation
- Roof insulation
- Ground floor insulation

Internal Insulation

Areas which are protected by conservation often preclude the ability to change the facades of the buildings. In order to overcome this, we have suggested using an internal insulation solution, such as the Earthwool Ecobatt and Ecostud developed by Knauf (figure 6).

The advantages of this system are that it prevents thermal bridging but also does not rely on the use of phenolic foams which as a team we have seen deteriorate around the edges in other projects. The minimum requirement would be for the insulation to achieve a wall u-value of at least 0.3 to meet Building Regulations. The use of this product to achieve this level would be 95mm.

There is one downside to this solution, and that is the 'removal' of thermal mass – by insulating internally the current exposed thermal mass (effectively paint on plaster on brick) on those internal facades means that the availability of thermal mass is reduced, and thus the ability of the dwelling to regulate its internal temperature also falls. On balance, however, it was decided to include the internal insulation as the benefits for residents are far greater in terms of reduced running costs.

External Wall Insulation

For facades that are not subject to conservation issues, this leaves more flexibility around how walls can be insulated. The preference for the strategy is to use external wall insulation to these elevations, reducing considerably the disruption to residents (where the building is occupied) and also not reducing internal floor space. For this strategy we have suggested the use of the Knauf Thermoshell Rock or RockPlus.

This Knauf breathable system enables moisture to pass through the construction removing the risk of interstitial condensation. The Thermoshell product also contains a water repellent additive. The use of a mineral wool type slab also has a minimal impact on the environment. The thickness of the insulation is proposed to be 110mm in order to achieve the 0.27 u-value required.

The use of external wall insulation also has added climate adaptive benefits – it helps make the structure more weatherproof, and helps to reduce heat gain in the warmer months. This benefit will be increased provided a light colour render is introduced, increasing the reflective nature of the wall.

"The UK has a particular security of supply problem known as the ***energy gap****...so there is a risk that electricity demand will sometimes exceed electricity supply, if adequate plans are not implemented....*

The Climate problem is mostly an energy problem."

David JC MacKay
Sustainable Energy - without the hot air (2009)

Roof Insulation

A simple introduction of deeper levels of mineral wool roof insulation is a recommendation, even in buildings that are relatively tall and thin and therefore as a proportion of envelope subject to heat loss the roofs are relatively small. However, the introduction of insulation is a cheap and simple measure and should be done as a matter of course.

The issue is therefore how the roof structure is addressed. Making amendments to a common roof space enables around 400mm of mineral wool insulation to be installed to achieve a U-value of 0.11. Where the roof space is not altered, then where this level is not possible, the maximum possible is to be installed.

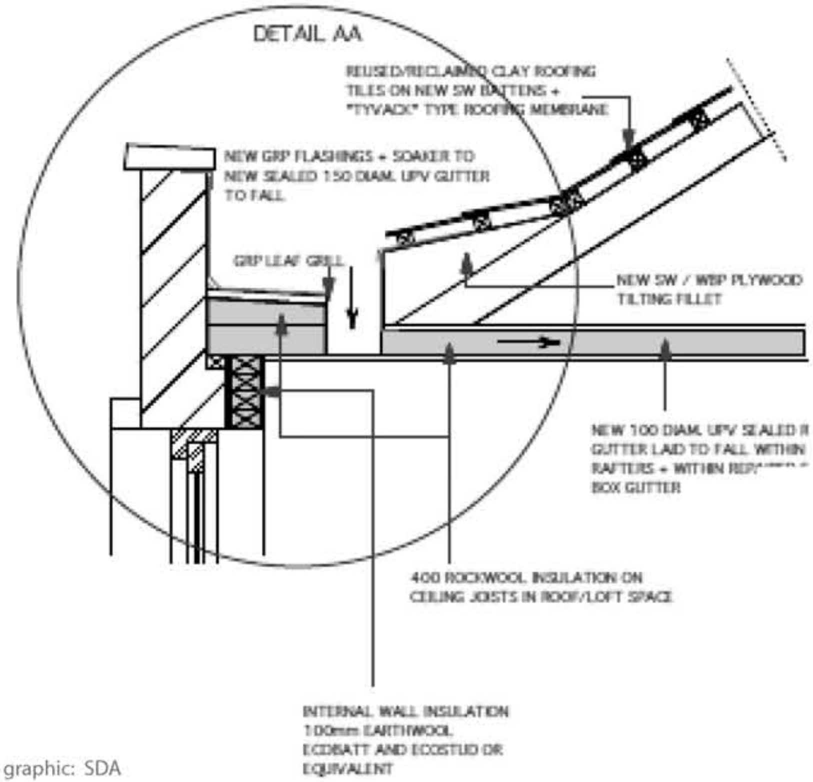
Loft insulation

Advantages and Opportunities

This is a well established, low cost measure that is simple to install and has a long life. There are significant energy and cost reduction benefits, although this is slightly less in tall thin Victorian buildings. There is scope for local suppliers and installers.

Design Issues and Challenges

Access may be a problem in existing properties, especially removal of clutter and stored items.



graphic: SDA

Retrofitting insulation under rafters

Mineral wool loft insulation

Ground Floor Insulation

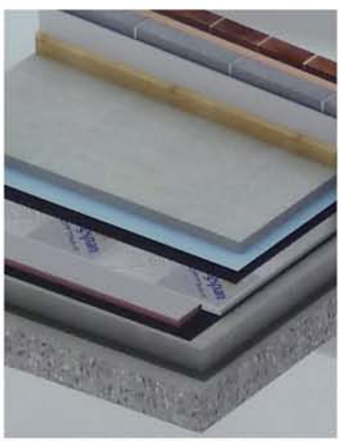
Where the state of an existing the floor warrants replacement, improved levels of insulation should be installed accordingly to achieve Building Regulations standards. This measure however, may not necessarily form part of a suite of measures for a refurbishment of occupied properties due to the level of disruption and high cost associated with implementation.

Advantages and Opportunities

There is some reduction in energy / costs by reducing heat loss to the ground. It is relatively easy to fit in suspended floors.

Design Issues and Challenges

This can be costly and disruptive for solid floors in occupied buildings. Care is requires over detailing and damp issues, especially where the insulation is at basement level which may require tanking first.



Kingspan solid floor insulation

External wall insulation

Advantages and Opportunities

This improves thermal performance and reduces energy use. UK based suppliers and local installers may be employed and there is some funding available from Utility companies until March 2015.

Design Issues and Challenges

Planning may be an issue depending on location, as the external appearance of a building can alter. Detailing can be complicated around new extensions, and adjacent to nearby properties. It is a relatively high cost measure, and care is needed for external elevation depending on the type of insulation and finish installed, with possible damage from bikes, ladders etc.

Serviwall external insulation with brick slips

Thermafleece natural UK wool (85%) with recycled polyester

Internal wall insulation

Advantages and Opportunities

This improves thermal performance and reduces energy use. Planning is not an issue, and UK based suppliers and more local installers can be used. There is some funding for energy saving measures available from Utility companies up until March 2015.

Design Issues and Challenges

Insulation does not reduce need for cooling in a warmer climate, as it can reduce thermal mass in rooms. Disruption can be significant for installation in occupied homes and redecoration costs need to be factored in to the total cost. In addition there are some concerns over interstitial condensation.

Thicker partition walls

Advantages and Opportunities

Replacing thin stud walls with thicker partitions can increase thermal mass depending on finish. This can result in better acoustic properties between rooms and is best installed in empty properties.

Design Issues and Challenges

There is a higher cost than standard partitions and reduction in room sizes. This is really only an option in empty properties. Structural loadings will need to be checked to ensure additional weight can be carried

Renewable energy and peak lopping

Photo voltaic Arrays

Advantages and Opportunities

Simple to install and replace, with an increasing number of installers available. There is a feed-in tariff to increase returns and installation costs are falling over time. This measure can help to offset any cooling load, and should be an integrated design feature.

Design Issues and Challenges

The impact on energy demand has to be assessed on a case by case basis. Maintenance costs can often higher than expected due to inverter replacement.

Solar Thermal Systems

Advantages and Opportunities

These are simple to install and to replace with most heating engineers offering installation and maintenance services.
There are RHI returns, and they help to offset any DHW load.

Design Issues and Challenges

Pipe work infrastructure needs careful consideration, and east-west roof orientations need a split system. This measure is only suitable where hot water storage is present or possible.

Air Source Heat Pump

Advantages and Opportunities

This removes the need for a gas supply and reduces energy use in kWh terms over conventional methods. It can be used for heating and cooling. Under floor heating systems or oversized radiators can be used.

Design Issues and Challenges

This is a high cost measure, with questionable performance in existing / occupied dwelling scenarios. Building air tightness needs to be very good, and the system must be designed installed and commissioned to a high standard. In the past, systems have been undersized, so this needs careful consideration. External units can be obtrusive and maintenance can be difficult, so some Registered Social Landlords prefer not to use them.

Air Tightness and Draught proofing

Advantages and Opportunities

This can reduce draughts, reduce energy use, and improve comfort. This is a relatively low cost measure in occupied buildings (draught proofing). It needs robust design code for refurbishment works, and continued development of standard detailing for improved air tightness.

Design Issues and Challenges

Air tightness can increase the overheating risk and reduce internal air quality.
It requires a high quality builder/ contractor to ensure higher performance, and needs to be part of a whole house refurbishment that ensures good quality managed air flows if building more air tight to reduce risk of dampness.

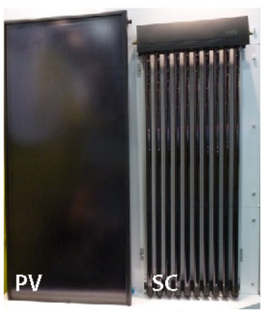
Air conditioning via VRF system

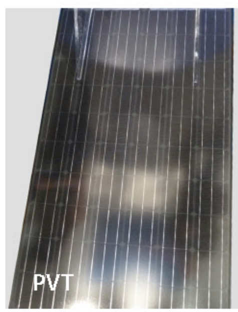
Advantages and Opportunities

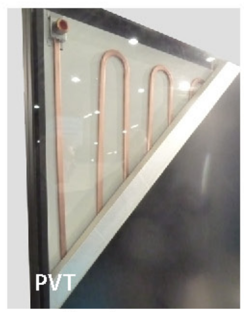
Air-conditioning guarantees spaces are habitable (in temperature terms) in 2080.

Design Issues and Challenges

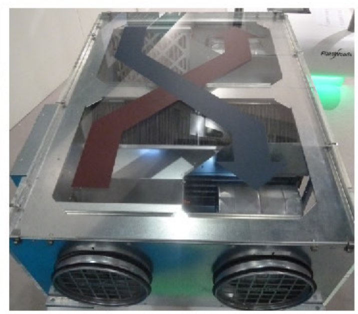
Installation in retrofit / occupied dwelling is disruptive, and there is a high running and maintenance cost. With fuel bills likely to increase significantly the impacts of future affordability should be considered. Replacement costs are high, and space is needed for the external units that has lead to visual blight in many warmer countries.







Photovoltaic and evacuated tube solar collectors to make electricty or hot water. Photovoltaic Thermal panels make hot water and elecricity.



Air to air heat exchanger

“Drought and Flood are twin terrors which seem to be occurring more often across the planet ...The UK has insufficient water...the statistical blip putting the UK in the insufficient (water) category is the concentration of the population in the south east of the country.”

Alexander Bell
Peak Water - how we built civilization on water and drained the world dry (2009)

Water Availability

The Risk

Water availability is an ever increasing problem and the challenges will only be greater in 70 years' time. It is simply common sense that we need to examine how potable (mains) water use can be reduced effectively, but without detriment to the users of a building.

In the long term fluctuations in rainfall are due to increase, resulting in the diminishing ability of groundwater reserves to be replenished properly. Increased storm events will probably lead to greater run-off into watercourses rather than absorption into the ground, compounding the problem.

The weather data predicts increased incidence of summer drought and lower soil moisture condition in summer and autumn, a period when higher ambient temperatures place greater water stress on trees and vegetation generally.

Rainfall is likely to be far more erratic, and steps will need to be taken to manage this for open spaces and gardens so any design approach should be around the principles of capture and storage of rainwater to 'even out' the flows.

The Solutions

Within the buildings themselves, there will need to be a focus on reducing demand for water in the first place and using the water that is required as efficiently as possible. The target described will be met through the use of the following:

- tap flow regulators
- low volume capacity baths
- reduced flow aerated showers
- low volume, dual flush WCs
- water efficient appliances (where installed)

Achieving better than this baseline will require the use of rainwater harvesting for reuse within the building, and here we therefore propose 3 different options depending on the building in question, and the available budget: Gold, Silver and Bronze.

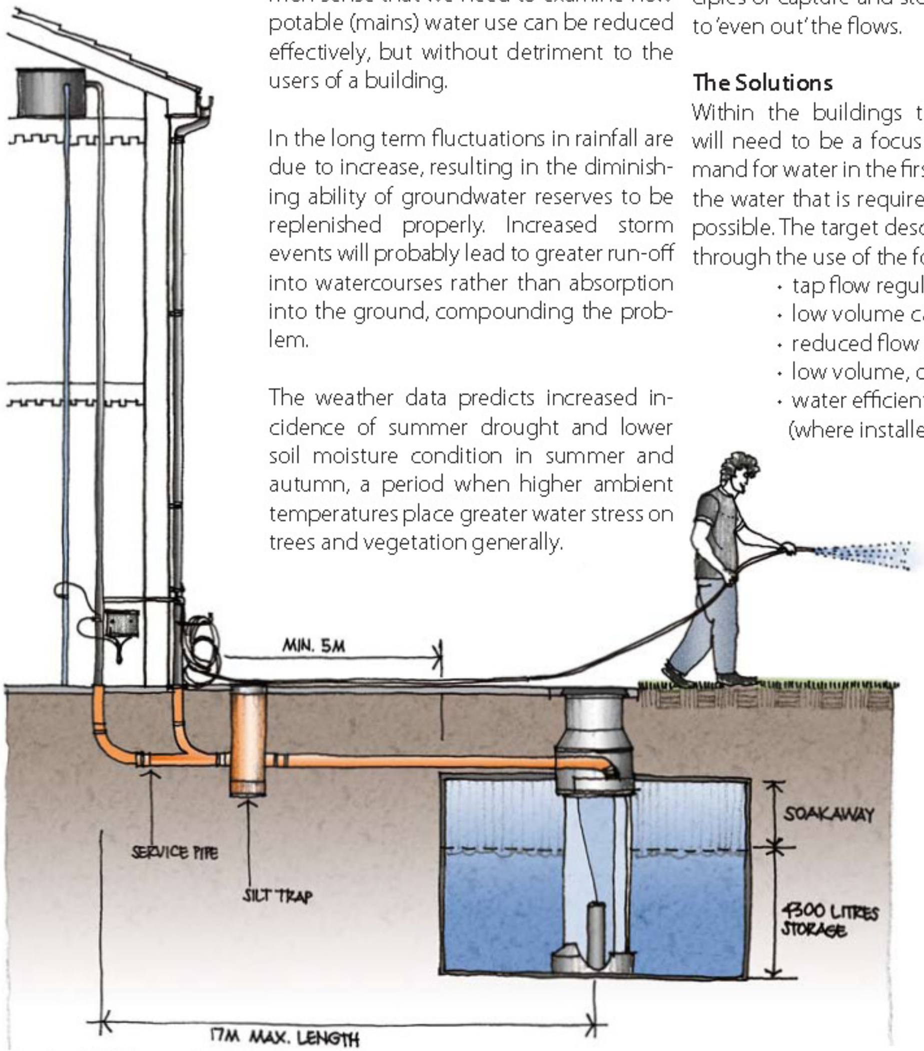
The 'Gold' Approach to Drainage

This approach includes for the provision of a soakaway, as required by the Building Regulations, but coupled to the use of a rainwater harvesting system for use within the WCs / washing machines within the property. This has the added benefit of not only reducing pressure on an existing drainage system, but also further reduces the amount of potable water used; an adaptation to the changing climate in itself. Coupled with the use of more efficient fixtures and fittings, we calculate that this would reduce water demand to approximately 85l/p/d.

The following diagrams show the location of this system, as well as detail of the system itself. In terms of the specification, the size and cost of a unit would obviously depend on the site in question, but for illustrative purposes we have used the Marley USW200 system. It combines both the rainwater harvesting storage and the soakaway system within one unit, thus reducing space requirements and making installation easier.

The 'Silver' Approach to Drainage

This approach is to include the use of the soakaway – as required by building regulations – but to remove the rainwater harvesting system. The cost of installing a



Marley USW200 rainwater harvesting system

graphic: studio engleback

simpler soakaway system – in principle a rubble filled hole to the required size within the rear garden is somewhat lower than that of the system within the 'Gold' Approach. Therefore the decision on whether to install this option will be based on budgetary constraints.

The 'Bronze' Approach to Drainage

Given past discussions with Building Regulations, it is clear that either the Gold or Silver approaches should be installed when feasible. However, in scenarios, where perhaps extensive works to buildings are not proposed a third solution needs to be found. This solution should also apply to those properties where the available space does not exist for the introduction of soakaways and/or rainwater harvesting systems.

This approach, therefore, would need to use existing drainage systems. Improvements in this case may require work on existing guttering to cope with both existing and future weather scenarios with storm water levels and risks of freezing. This will help manage the flows of water from the roof to ground level, and improve the resilience of the building / roof structure, however it does not provide any additional attenuation for storm / higher water flows.

Lower flow bathroom tap with PIR sensor.

Low Flow Fixtures, Fittings & Metering

Advantages and Opportunities

Low flow fittings are easy to replace with some fixtures and fittings having a low cost. Utility appliances are increasingly water efficient and can help deliver a rapid reduction in water use. Water metering can also be beneficial in encouraging more water efficient behaviour, helping decision making on replacement of older appliances.

Design Issues and Challenges

Performance standards may not be acceptable for current habits (e.g. low flow showers). There may be some reluctance to accept metering in households with larger numbers of inhabitants, but Water Companies are looking to completely replace the water rate system over time.

Rainwater Harvesting System

Advantages and Opportunities

There is an opportunity to install and integrate rainwater harvesting if a whole house is being refurbished, which can lead to significant reductions in water use. Simpler for use just in the garden, but more complex if harvested water is to be used to flush toilets. Currently around a third of all water used in homes is used to flush toilets. Water harvesting relieves pressure on wider water management systems, but is not counted as a component of a sustainable drainage system since storage tanks may be full when attenuation is needed.

Design Issues and Challenges

A major integrated system can be costly, and disruptive to install on a retrofit basis if the cistern is located underground, but above ground tanks are clearly an easier choice. Additional plumbing infrastructure needs to be accommodated in each unit as a separate pipe system is needed along with filters, UV treatment and colouring of non-potable water.

Soakaways

Advantages and Opportunities

Relieve pressure on existing water management systems as long as there is capacity in the ground water. The chalk below Dalby Square is useful in this regard.
This is a far more sustainable means of dealing with surface water runoff where alternative is a pumped system to treatment works. Support from Building Regulations (may also be a necessity in certain retrofit scenarios that involve/require Building Control consultation).

Design Issues and Challenges

Needs sufficient space away from the main building structure to be effective.

Lowara rainwater harvesting tank with cut-away side showing plumbing

Climate Change is forecast to cause an increase in storm events. There has been a measurable change in storm tracking over the UK in the past 20 years with an increase in storms passing up the English Channel and into the North Sea. In Scotland where higher average wind speeds are more prevalent than in the south, buildings have been constructed differently, notably using sarking boards fixed at 45˚ to the rafters under the roofing, this detail not being common in the south. Repair of older houses may need to consider some structural changes in the future. In recent years the frequency and severity of large storms and the amount of damage caused by them has increased impacting the insurance industry through increased claims

Building Detailing

The Risk

Depending on the level of exposure of a building there will still be a need to examine the existing detailing on the buildings, and their performance in terms of weatherproofing, because of the anticipated changes to the climate. As buildings are refurbished there is a good opportunity to address construction details - including insulation, renders, reveals and eaves details - to ensure longevity and greater resilience.

A variety of adaptation measures will need to be considered such as adding shading, damp proofing foundations, replacing / upgrading roof coverings, flashings, etc, enhancing the thermal performance and air tightness of the existing brick walls with internal and external insulation, replacing / enhancing the performance of window / roof glazing, and building heating, cooling and water systems.

The Solutions

These include Roof Design, Guttering and Flashings.

Roof Design

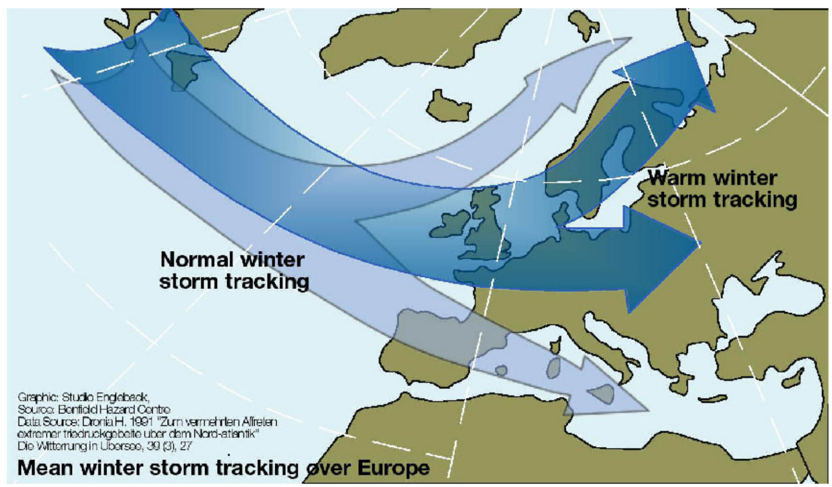
Existing roof configurations may be vulnerable to blocking and flooding. These issues may be overcome to some extent by constructing for example mono pitched platforms which span between ridges of the double pitched roofs and gullies. This technique can be used to discharge rainwater into existing refurbished rain water management systems.

Guttering / Flashings

Older rainwater pipes may to be replaced by PVC and the existing faulty lead flashings should be replaced with new GRP flashings and soakers as these are less prone to thermal movements, and vandalism/ theft.

Costs and Paybacks

In consideration of the forecasted future climate changes, it became clear that any measures that are installed will need to be done with climate change adaptation as 'an added benefit' rather than as the primary driver for installation. Thus we need to examine the multi functionality of the measures rather than as adaptation measures per se. The same applies to the landscape. This core principle should be applied in all residential refurbishment scenarios when looking at the financial returns on investment.



So the levels of funding required (and described in this guide for individual properties) are difficult to justify purely on a climate change adaptation basis when considering assets in areas where property values are significantly lower than the regional average.

Paybacks can be calculated in energy saving terms, albeit these stretch into the tens of years for most of the measures. The total annual savings from the combination of measures is around £400-500 per property. So, for an area with low levels of income and high levels of fuel poverty, alternative approaches to value need to be established and alternative sources of funding need to be accessed.

This does not fundamentally mean, however, that climate change adaptation measures should be ignored. Quite the contrary, they have significant non-financial benefits that can accrue:

- The reduction in energy running costs of the building
- The improvement in the physical struc ture of the building and the reduction in maintenance costs
- The improvement to the building aesthetic
- The improvement to quality of life for residents where the risk of damp and excess moisture is reduced
- The ability of the building to adapt to climate change and maintain habitability

The majority of the measures described in detail above are the result of good practice in refurbishment and energy efficient retrofit, and should be carried out for the above reasons in due course and as standard practice as the building is maintained. We believe adaptation to climate change should not, therefore, be a separate issue to be addressed on an individual basis – especially in retrofit scenarios for residential buildings.

New roof covering - slate

Advantages and Opportunities

Medium to high cost measure , but has a long life.

Design Issues and Challenges

Area of roof potentially limited under new design proposals. There is a risk of wind driven rain penetration during heavy storm events.

Roof Flashings + Soakers

Advantages and Opportunities

This should be part of a standard building maintenance routine using proprietary systems supplied and installed by local businesses. A long to intermediate term intervention, with a 25 year minimum life expectancy. One replacement installation would be anticipated before 2080. The benefits include energy cost reductions.

Design Issues and Challenges

Potentially medium to high cost measure because of the need for scaffolding. Although simple to install, flashings are medium to high risk and dependant on standard of on-site installation. Access to maintenance critical. There is always a risk of wind driven rainwater penetration, the potential for blockage / leakage.

Roof glazing

Advantages and Opportunities

Enhanced quality of living environment that is relatively simple to install, using well established techniques. They have an intermediate 25 year plus life expectancy. At least one replacement installation may be anticipated before 2080.

Design Issues and Challenges

Potential for adverse increased thermal heat build up without blinds.

Roof Gutters + Down pipes

Advantages and Opportunities

Long to intermediate 25 year life expectancy, with a single anticipated replacement installation before 2080. Likely heavier rain events may require larger guttering and down pipes to prevent overflowing.

Design Issues and Challenges

Although most guttering and down pipes in the country are now made of PVC coloured to reduce painting requirement from cast irn pipework used in most Georgian and Victorian buidlings through to the 1970s. This material, however, does become brittle when exposed to UV light. Metal detailing using galvanised steel or copper pipework is still common across mainland Europe and this has a much longer life, but a higher initial cost.

Summary Table of Risks & Costs

Risk Matrix
Each solution has been identified according to the risk it addresses.

In addition each has been ranked according to the impact it has on that risk (high/medium/low) and on the basis of cost (low/medium/high). These have been combined to then provide a priority score (1 – highest priority to 5 – lowest priority) based on the matrix opposite

impact \ cost	low	medium	high
low	3	5	5
medium	2	3	4
high	1	2	3

Adaptation measures	Overheating	The ability to keep warm / reduce energy bills	Water availability and management	Risk to the building structure
Shading – internal blinds	3	3		
Shading – external brise-soleil / shutters	2			
Mechanical Ventilation/Heat Recovery Systems	5			
Solar Glazing	4			
LED Lighting	3			
Internal wall insulation		3		
External wall insulation	4	3		
Loft insulation	3	1		
Ground floor insulation		4		
Thicker partition walls (where replaced)	5			
Air Tightness and Draughtproofing		3		
Photovoltaic		3		
Solar Thermal Systems		4		
Air conditioning via VRF system	3			
Air Source Heat Pump		5		
Low Flow Fixtures and Fittings and Metering			1	
Rainwater Harvesting System			3	
Soakaways			3	
Roof Gutters + Downpipes			2	2
New roof covering - slate				3
Roof glazing				4
Roof Flashings + Soakers				4

"Adapting to the consequences of climate change requires anticipation, investment (in information, equipment and infrastructure) and organisation... It will in many cases involve radical changes in patterns of economic activity and ways of living."

Nicholas Stern
A Blueprint for a safer planet - how to manage climate change & create a new era of progress and prosperity (2009)

"The findings (of the European project, RUROS) confirm a strong relationship between microclimatic and comfort conditions, with air temperature and solar radiation being important determinants of comfort, although one parameter alone is not sufficient for the assessment of thermal comfort conditions."

Nikolopoulou, M. and Lykoudis, S., 2006. Thermal comfort in outdoor urban spaces: Analysis across different European countries. Building and Environment, 41 (11), pp. 1455-1470.

Seeking Shade in the Parc de Rueilly
photo: studio engleback

"Climate Change poses a threat to human comfort in urban areas...the urban heat island effect has the potential to compound and accelerate (urban) temperature rises...research has established that the creative use of greenspace is a vital climate change adaptation strategy. It is significant that greenspace provides multi-functional benefits, for example by enhancing human health and providing habitats for flora and fauna"

To tackle the problems of climate change, our urban condition and resource scarcity, it is important to have an understanding of the interrelationship and interdependence of natural, or Earth, systems and human, or World, systems. Both systems are complex, so this means there is also uncertainty and surprise.

The range of effects climate change is bringing with it will affect us all, and it requires us to adapt to changes that are already in train over the next 30-40 years due to past carbon emissions, as well as how to reduce future carbon emissions to reduce the severity of future predicted changes beyond that time frame.

Multi- functional environmental infrastructure, provides a variety of environmental services. Sometimes this is referred to as Green Infrastructure, and until recently the value of this way of thinking has not been fully appreciated, but this is changing.

More than simply adding to the urban design aesthetic a tree, for example, can filter dust from air, reduce urban heating, assist in reducing energy use in buildings, act as a wildlife resource, and help to attenuate surface water run-off. The important thing is the cumulative effect of well planned environmental infrastructure, for this is where its effects can really be seen.

As long ago as the 1820s it was noted that urban temperatures are higher than the surrounding countryside. This is referred to as the Urban Heat Island Effect. The hard materials of buildings and roads absorb and store heat from the sun more readily than green areas. The colour of hard materials affects how much heat is reflected and how much is gained. The warmed materials then re-radiate heat when temperatures fall at night, heating the air.

The reflective quality of a material is called the albedo. Darker colours have a low albedo and will absorb more heat than, white which has a high albedo. Although greenery is quite dark, is keeps cool because it is constantly losing water from the leaf surfaces, a process referred to as evapo-transpiration. The evaporation of water vapour from the leaves provides cooling to the plant and surrounding area. Greenery can only provide cooling if it has a supply of water in the soil to transpire.

Climate change will alter the amount of water in the soil, or soil moisture, as we have seen in the drought of 2011, then wet summer of 2012. It may exaggerate wet and dry periods.

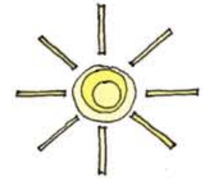
Heavy rain events has become more prevalent in recent years because a warmer atmosphere can hold more water vapour. When soils are dry they are less good at absorbing water, and the rapid run off of water from heavy rain on dry soils can cause flash flooding. When the soil is full of water, and it can take no more, this can also cause flooding.

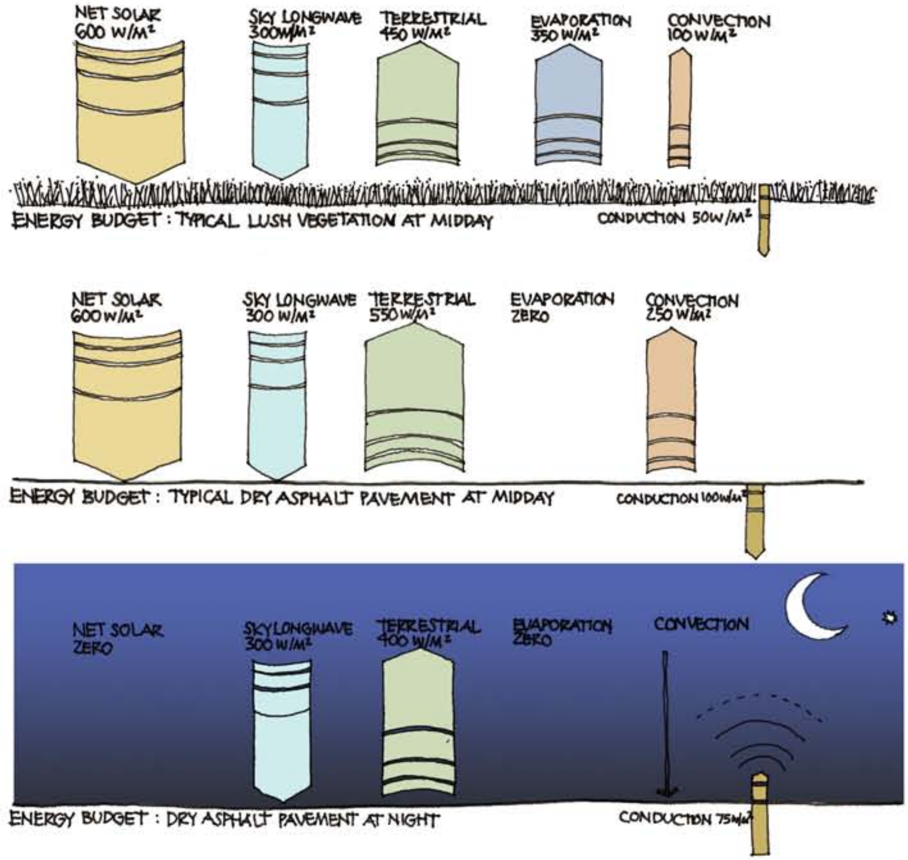
Understanding these basic ideas is key to adapting urban spaces to climate change. If surface water is diverted to green areas, and the soils in these areas is improved so that it can absorb water even after a dry spell, we can reduce flooding and recharge the soil water more quickly.

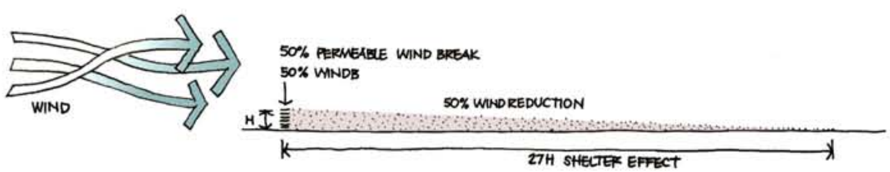
If soils are deep and well drained, plant roots grow deeper and so can survive periods of drought better without wilting, or dying. This means that we can benefit from some cooling from plants as water passes from the roots to the leaves and into the atmosphere. This is referred to as evaporative cooling. A large tree can provide the same amount of cooling on a hot day as five large air condition units running for 19 hours, and without the exhaust hot air, it can also stop hard areas from heating up through shading.

Changing the way surfaces in urban areas deal with energy from the sun is a key adaptation method. Every square metre of the ground in the south east of England receives, on average, around 1,200kWh of solar heat energy every year. In a built up environment, with many hard surfaces such as concrete, brick and asphalt, a great deal of heat can be absorbed and re-emitted into the local environment, causing higher air temperatures. If this heat is not removed by a combination of wind and cooler temperatures at night, then overheating problems can arise in summer. In the winter, this isn't a problem, as greater heat storage needs to be encouraged to create a warmer, more comfortable environment. The incoming energy budget is partioned according to the surfaces it meets. The diagram opposite shows the typical energy distribution according to surface area type.

Extending the winter outdoor season is the other objective of modifying a microclimate. At the beginning of spring and the end of the autumn, cold winds from the north and east prevail. Sheltering spaces and creating sun traps in winter enables people to enjoy bright winter days in more comfort. To avoid turbulent wind eddies at ground level the best shelters are about 50% porous and help to nudge the wind over the park space.







A taxonomy of climate change adaptation measures for the public realm

Adaptation measures	water	carbon	food	energy	biodiversity	social	flexibility
Rainwater harvesting	✔		✔		✔	✔	✔
Surface water storage	✔		✔		✔	✔	✔
Grey water recycling system	✔	✔		✔		✔	✔
SUDs play	✔				✔	✔	✔
Storm crates	✔					✔	✔
Green roofs		✔	✔	✔	✔	✔	✔
Wider drain pipes	✔						✔
Surface channels	✔	✔					✔
Swales	✔				✔	✔	✔
Rain gardens	✔	✔		✔	✔	✔	✔
Biochar	✔	✔	✔		✔		
Herbs	✔	✔	✔		✔	✔	✔
Fruit tree orchard	✔	✔	✔	✔	✔	✔	✔
Espalier fruit trees	✔	✔	✔	✔	✔	✔	✔
Polytunnels	✔	✔	✔	✔		✔	✔
Green houses	✔	✔	✔	✔		✔	✔
Cool houses	✔	✔	✔	✔		✔	✔
Over car parking shade structure	✔	✔		✔	✔	✔	✔
Over pedestrian shade structure	✔	✔	✔	✔	✔	✔	✔
Tree shelter belt	✔	✔		✔	✔	✔	✔
Built form shelter belt		✔	✔	✔	✔	✔	✔
Woodland	✔	✔	✔	✔	✔	✔	✔
Wild meadow	✔	✔		✔	✔	✔	✔
Xeriscape planting	✔			✔	✔	✔	✔
Low energy street lighting		✔		✔		✔	✔
Football play space						✔	✔
Green walls		✔	✔	✔	✔	✔	✔
Wind turbines		✔		✔		✔	
Photovoltaic panels	✔	✔	✔	✔	✔		✔
Ground source heat pumps		✔		✔		✔	

Landscape Drivers

The first stage of work considered the drivers for change and adaptation to future climate change, as well as over-lapping considerations of the world changes that will affect the way we live.

The table opposite sets out a possible taxonomy of adaptation measures with an indication as to their relative value. In particular these measure need to address:

1. Soils
2. Water
3. Social
4. Food

(reduce reliance from external sources)

Landscape measures

1. Weather - shelter from wind, sun traps, water storage.

2. Harvesting -heat, energy, water, food, and carbon

3. Soil improvement

4. Social spaces - for events, and as a precursor for people acting together.

Adaptation rating criteria

1. Life time cost (up front cost and replacement cost)
2. Cost in use + running cost
3. Energy saving $C0_2$
4. Cost saving
5. Multi-functional benefit
6. Benefit to local economy
7. Adaptation (fix at say -10ºC)

The table opposite lists a series of adaptation measures for the public realm using a yes/no assessment applied to their potential use for water, carbon, food, energy, biodiversity, social concerns and whether the measure might be flexible in terms of implementation of changing use over time.

A more detailed assessment was made for the whole study including the buildings for which a score of between 0 and 5 was given for the benefits that might be derived from different measures. The landscape measures had a high value for including in the design. With these in mind three options that had been designed for the public realm were assessed using a SWOT (Strength Weaknesses, Opportunities, Threats) Analysis, which coupled with the pragmatism of costing informed the design that was finally put forward. There was a degree of flexibility built into those proposals so that some measures might be adopted at a later date.

Dealing with water is another vital function that urban space needs to engage with. Heavy rain events cause localised flooding, especially after periods of drought because paving and housing seals the ground surface, and hard dry soils cannot absorb the rainfall quickly. More often than not, water is directed into a drain system.

Surface water from paved surfaces may pick up pollution that is concentrated when collected by drains, diffusing the areas in which it is dispersed reduces point loading of containments like oil from cars, and at low levels these can be digested by bacteria in the soil.

Sustainable Urban Drainage seeks to slow down surface water flows so that a pulse of heavy rainfall can be evened out, giving natural systems more time to absorb them. The aim is to re-charge the ground with water and to make this available to plants.

There are a range of method of doing this, and in allowing the urban environment to hang on to water over a larger area, the risks of concentrating flows are minimised, and the chances of using evaporation as a technique for cooling is maximised.

Ideally the aim is to hold onto the rain drop as close to where it fell as possible. Green roofs and porous paving extend the absorbing qualities of gardens. Shallow basins or ditches, graded stones under roads and underground cisterns all provide on site capacity to make an area more resilient to heavy rainfall.

A storm swale

A rain garden

An infiltration lawn

Porous Paving

Trees in porous paving

Large stones under paving

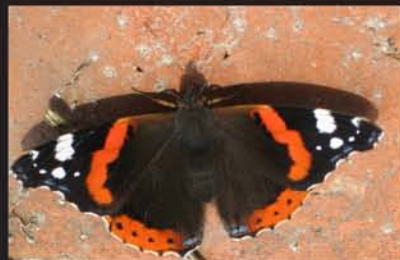
Sedum roof

A storm crate

A dished channel

A mix of surface water attenuation measures provides the opportunity for a more interesting urban environment whilst being functional, and often less expensive to built and to maintain than conventional underground pipework.

It we are seeking to harvest water for more sensitive uses - such as watering food plants, then we need to consider collecting it from roofs and storing it underground where it can be accessed using old fashioned hand pumps.



Biodiversity is the richness of wildlife which has been squeezed by modern living, and climate change may happen faster than many species can adapt to. Making habitats for wildlife provides greater resilience in the face of rapid change. For example, adding crinkles to our smooth urban surfaces provides space for over-wintering Red Admiral butterflies, lady birds, lacewings, or bumble bees. Over 70% of the food we eat relies on pollination by insects.

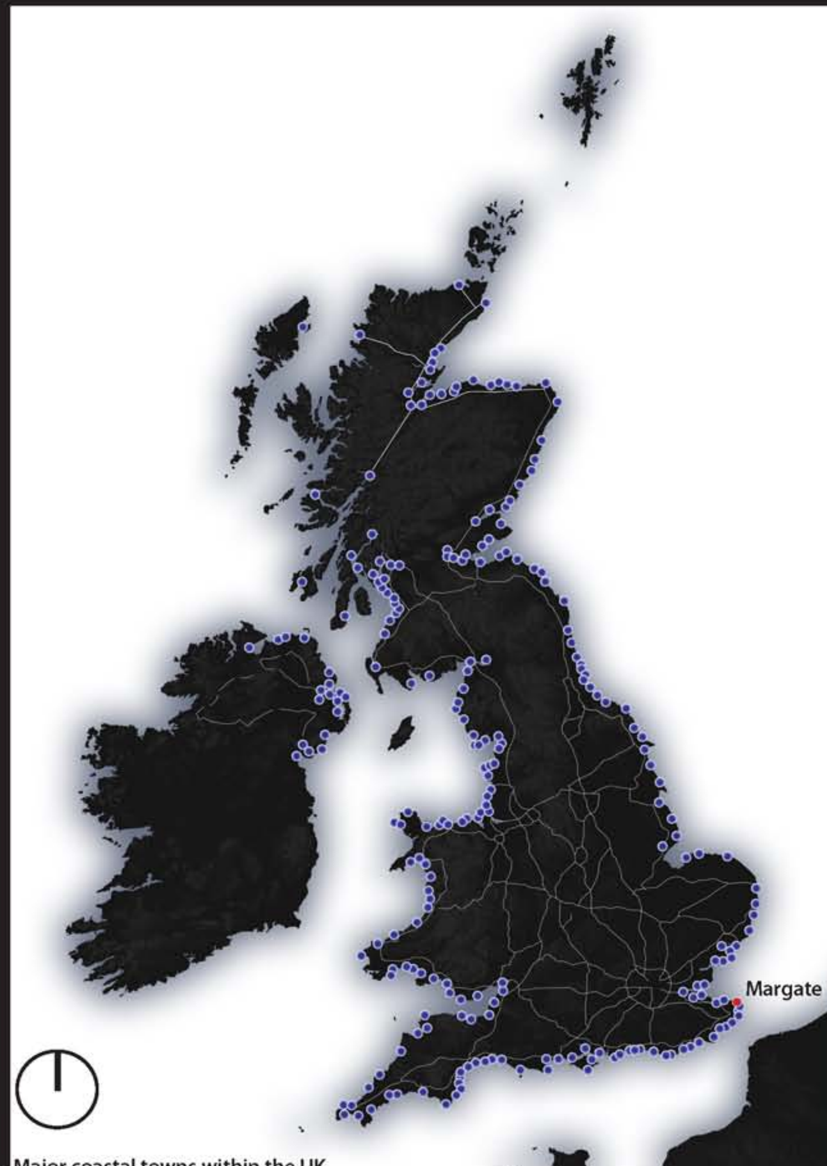
Urban food is becoming a hugely popular activity. It provides a focus for urban communities, helps us to eat healthily and reduces the road miles associated with the delivery of food from further afield. Most importantly it puts us back in touch with Nature - out ;life support system. Climate change is already affecting harvests due to very wet, dry or hot conditions, urban food adds a little more resilience and is part of a package of adaptation measures for climate change.

Case Study: Cliftonville

The study site in Cliftonville, Margate is typical of many Victorian Seaside Resorts around the country. Low lying areas are at risk of flooding as a consequence of rising sea levels and the forecast increased incidence of storm events. Cliftonville is located well above sea level, but many of the services that supply it are not, suggesting that a key adaptation to future climate change is to consider increasing resilience and reducing dependence on remote supply sites. The recent tsunami in Japan may not be related to climate change, but the significant disruption to supplies of energy and food have prompted a move to reduce dependence and increase local independence in energy and food supplies. Because the UK is dependent on a devolved supply of good and services from areas in the world prone to greater challenges from climate change, adaptation needs to go beyond addressing local problems.

As a Nation of islands we would expect to see a large number of coastal towns and cities, to which we could also add towns and cities on tidal rivers and river estuaries. Compared to its area, the United Kingdom has a very long coastline. The coastline of the principal islands is 31 368 kilometres, of this, 10 077 kilometres is the coastline of England, 2749 kilometres for mainland Wales, 18588 km for mainland Scotland, and 650 km for Northern Ireland.

The total coastline for the whole United Kingdom compares to the Italian coast of 7 600km, the Spanish coast of 4 964km, and of just 3 427km for France the largest of these countries. This places our study



Major coastal towns within the UK
graphic: studio engleback

in context. Although there are coastal resorts in each of the four Home Nations, the greatest centres of population for coastal resorts are located on the South Coast of England. With the exception of the west and northern coasts of Scotland there is a fairly even distribution of coastal towns. If we refine the search to look at coastal resorts these predominate on the south and east coasts of England and the coast of Lancashire. Whilst the individual environments of these coastal towns varies we feel that the over arching issues addressed in our study have a wider application than just the Isle of Thanet.

The approach we have taken is indicative of what might be applied elsewhere. Resilience in the next 40 years will be about a number of inter-related issues that affect the everyday lives of people. It is essential to grasp this point.

Climate disruption as a consequence of anthropogenic warming has several knock on effects that can exaggerate other issues such as resource depletion, the immediate and long term problems of energy supply, of food production, and human epidemiology. The wet year of 2012 has seen a 20% decrease in sowing grains in this country due to inaccessible fields, This will rise the cost of staples and feed for livestock.

We are currently experiencing the coldest Spring for quarter of a century, after he wettest summer for a century, but that followed one of the driest winters, and a few years before we had the hottest summer on record.

An altered climate here may well make some diseases more prevalent, and the increasing resistance of antibiotics to bacterial infection is yet another threat, from soil or food borne maladies, or for pests and diseases that affect plants themselves.

We can only deal with the whole problem when addressing environmental concerns, creating artificial silos of interest is very dangerous and can lead to avoiding seeing the 'elephant in the room'. The layers of function we added to the square are indicative of this approach.

It is vital that we move beyond a purely aesthetic approach to the external environment, seeing it as intimately connected to the how the cities work. This pragmatic ecourbanism approach to landscape engineering should result in multi-functional Environmental Infrastructure that delivers a series of environmental services.

This infrastructure need not be limited to vegetation, because the assemblage and consideration of materials, massing, aspect, orientation and so forth play a part in local microclimate and also impacts on energy use and dealing with surface water.

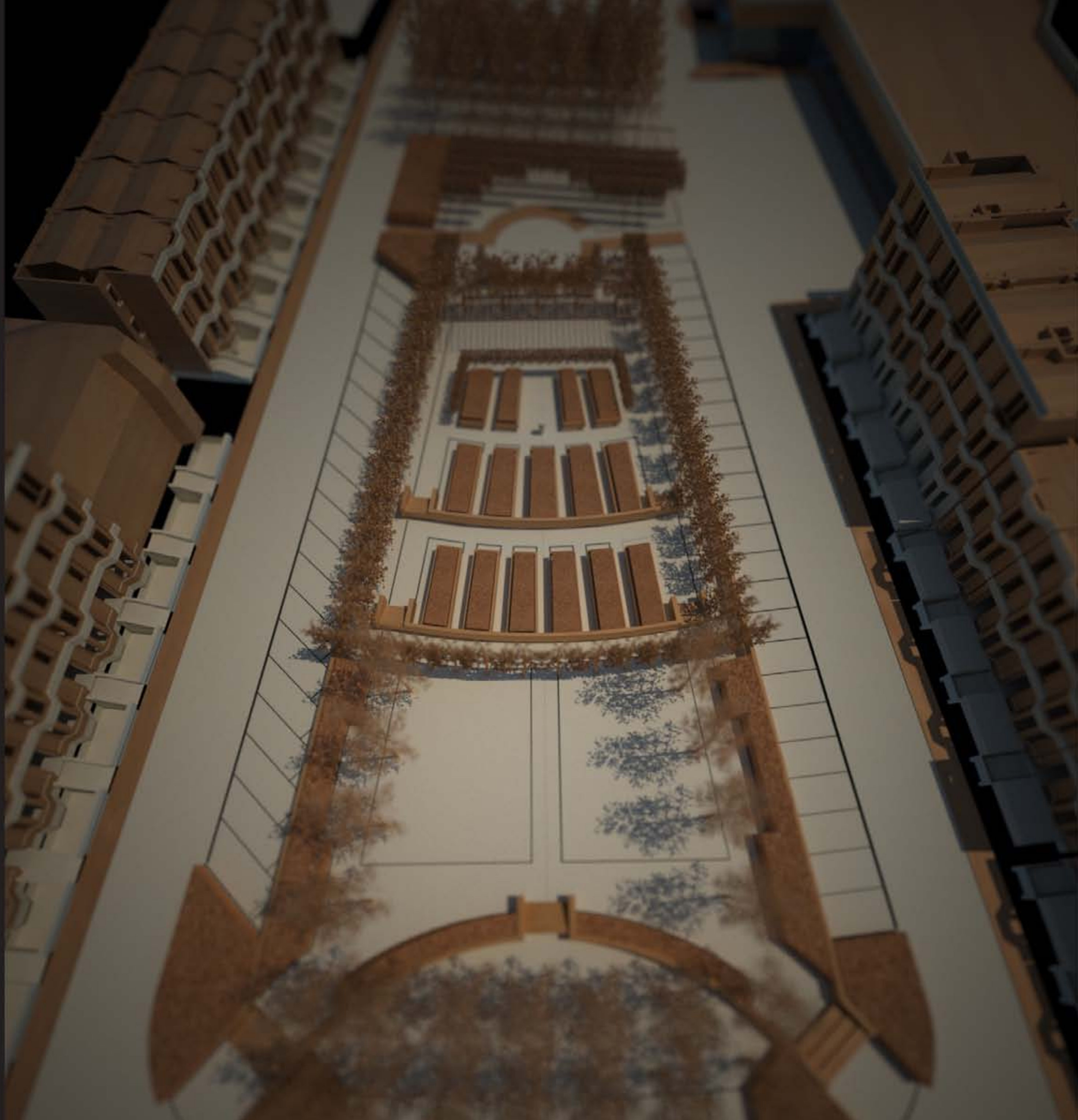
The role of the public realm supporting urban areas in adaptation to, and mitigation of, climate change can be significant, not least because of the considerable land area in towns and cities occupied by streets, squares, parks and greenways into the countryside.

The economic value of this environmental infrastructure needs to be considered at a wider scale as encouragement to investment in this adaptation to climate change, along with consideration of techniques that may yield cost savings for installation and management.

Research in the northwest by Ecotec and Amion has looked at how environmental infrastructure can add real value to the local economy supporting over 100 000 jobs and a direct gross added value calculated as £2.6 billion. Nicholas Stern has highlighted the imperative to act now and take advantage of the economic downturn to build for the future in his report *"The Economics of Climate Change'.*

The move to consider environmental infrastructure has advanced significantly since this author was pioneering this approach in the mid 1990s, and in addition to Stern there have been vital contributions from ASSCUE on reducing urban heat island through planting, recognition of the value of ecosystem services in The Economics of Ecosystems and Biodiversity (2010) and the UK National Ecological Assessment (2011) as well as position statements on green Infrastructure by CABE (Grey to Green), and the Landscape Institute.

Here is an opportunity to effect beneficial change on the scale of the Victorian investment in infrastructure, much of which we still use today.



The Dalby Square gardens have been improved in recent years, so the purpose of our interventions was to invest the space with functions that had an adaptive capacity for future climate change. Ideally this would have been part of the recent renovation rationale.

From a practical point of view, financial constraints meant that any intervention had to be made with the framework of the current garden square with minimal demolition and loss of features already installed. Even within this tight framework, interventions could be phased to suit cash flow and the politics of change.

For the purposes of this study, the field of interventions was narrowed to future investment in local food production plus water harvesting to irrigate this, improvement of the microclimate to aid food growing as well as to improve human comfort, and carbon storage to improve the soils.

Biodiversity value was seen as either improving the pollination prospects for food crops, or in increasing the ephemeral delight of bird song in the gardens by providing a food source, whilst renewable energy harvesting was restricted to provision of public lighting.

Food Harvest

Potagers, orchard trees and fruiting hedges for new community garden. An adaptation to effect behavioural change by heightening recognition that we must become more resilient and self reliant. The National Ecological Assessment 2011 stated that the 33% of the food and fibre we use is imported and this accounts for 66% of the water used by the UK, located elsewhere in the world, often in areas more adversely affected by climate change than we are.

Water Harvest

As an Island and in one of the drier parts of the country, Thanet needs to make best use of all natural resources. The square design included rain water harvesting with hand pumps to irrigate potagers, fruit and vines. Rain gardens for sustainable drainage help to irrigate the wider park.

Energy Harvest

Existing external light fittings replaced with solar. There is the potential to harvest more solar energy on pergola mounted PVs in the future.

Microclimate

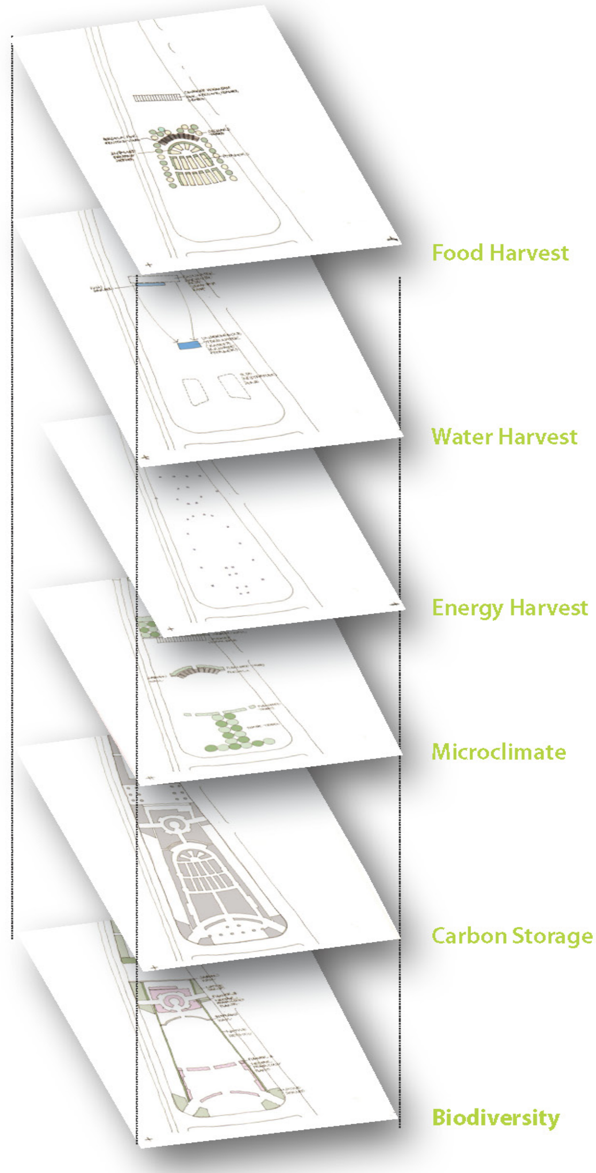
Shelter belt, gabion wall and pleached tree planting to protect against wind. Pergola and shade trees to provide shaded places to walk, sit and play.

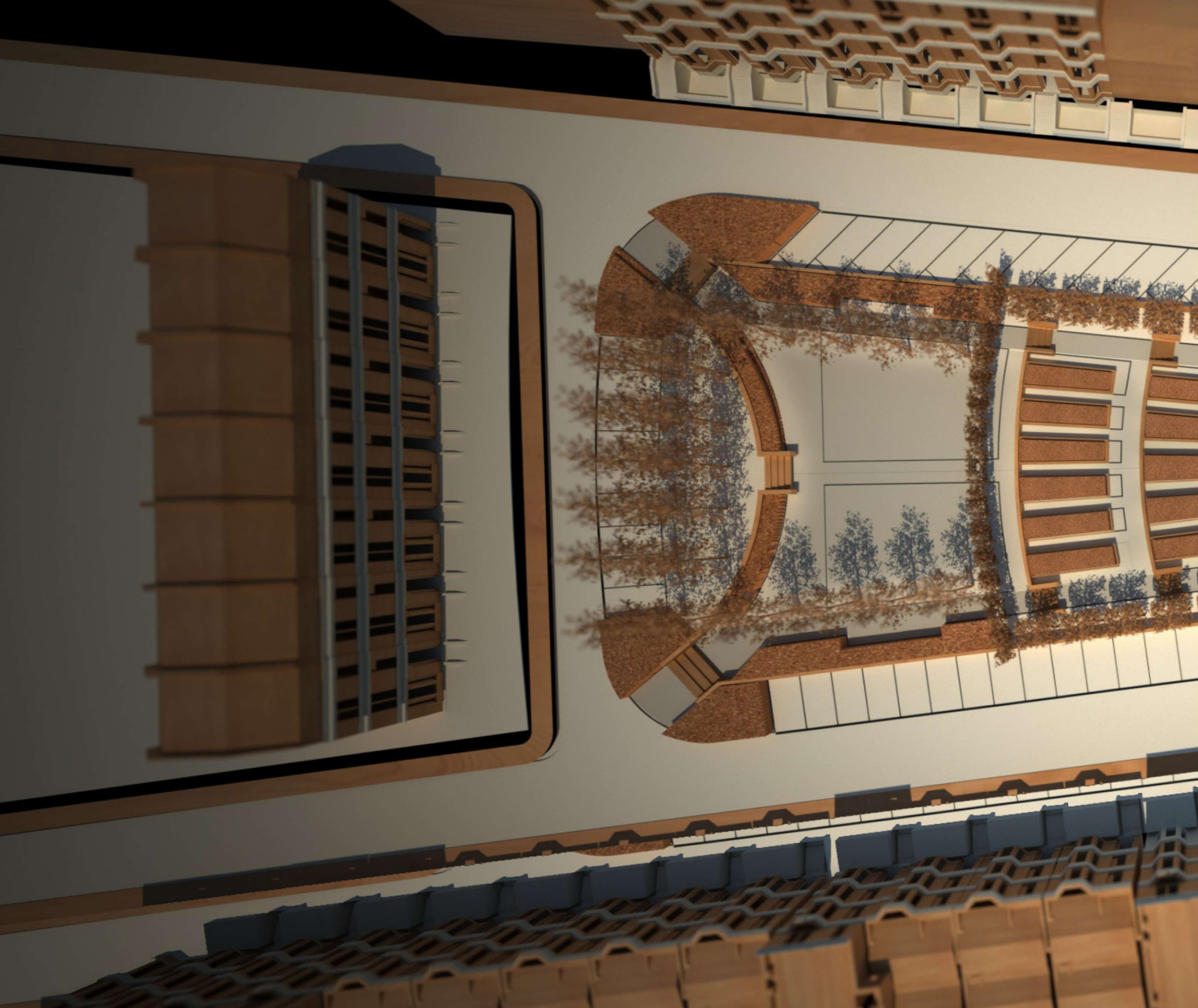
Carbon Storage

Biochar enrichment of all planted areas to increase carbon storage in the long term and concurrently increase fertility and water holding properties of the soil.

Biodiversity

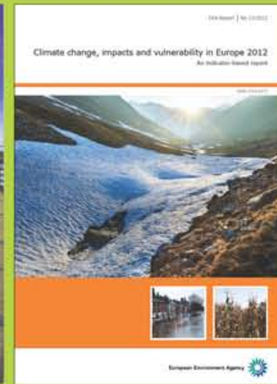
Bioporous gabion walls, native tree, hedge and shrub planting enhances biodiversity. Biodiversity is essential for pollination of over 70% of food plants, so making all recreational environments more biodiverse is a key adaptation.






Proposal to retrofit Dalby Square for future climate change
Design : Studio Engleback
Model : Simon Beames

References and further reading



The Technology Strategy Board bid was lead by Phil Jackson of Daedalus Environmental with Stephen Sadler of Radius Regeneration acting as project manager. The main aim of the project for Thanet District Council was to look at how two properties in Dalby Square in Cliftonville might be retrofitted to address future climate change. Phil Jackson led on the thermal modelling and Stephen Donald from SDA was the architect. Costings were provided by Anthony Perry from the WT Partnership. The Kent Architecture School was represented at the start of the project by Professor Don Gray.

The retrofitting of the garden square was an adjunct to this main work stream and was led by Studio Engleback, who also set out the environmental context to the overall study having previously embodied this thinking in their award winning work on the Greater Ashford Development Framework 2003-5 presented at the BRE Resource05 conference and Internationals Congress on Urban Forestry and Climate Change in Rome 2007, subsequent work with Phil Jackson on the Ebbsfleet development for Land Securities in 2008, and a paper on Adapting public realm to Climate Change at the 2009 Landscape Institute conference on Climate Change, as well as earlier work on TSB funded projects with Phil Jackson and Stephen Sadler in Queensborough in 2010. Studio Engleback also presented work with their masters students at the Bergen Arkitekt Skole at the Climate Exchange at the time of COP15 in Copenhagen in 2009, adaptation to climate change having informed their work since Studio Engleback became a full time entity in January 1999.

The TSB published a report written by Bill Gething entitled *'Design for future climate - opportunities for adaptation in the built environment'* (6/2010) that formed the starting point for twenty four TSB funded studies, of which the Cliftonville project was one, with the aim of sharing findings.

The pace of information and advice on climate change adaptation has increased in recent years. Studio Engleback wrote a paper in 2004 as part of the Great Ashford Development Framework for English Partnerships emphasising the need for planning for climate change adaptation in the long term, the concern for the insurance industry, and of meeting the challenges of year to year variability.

The UN Intergovernmental Panel on Climate Change (IPCC) fourth bulletin (2007) devotes one of its three volumes to Impacts, Adaptation and Vulnerability. The Stern Report on the Economics of Climate Change (2007) set out the cost benefits of addressing adaptations a priority. The IPCC Fifth Assessment will be published in March 2014.

The Town and Country Planning Association published a guide on climate change adaptation by design prepared by Shaw, Colley and Connell in 2007 with input from CABE, the Environment Agency, RICS and English Partnerships. This document looks at management of higher temperatures at building and neighbourhood scale, managing flood risks; water resources and quality; ground conditions, and provides an over view of available technologies.

Coinciding with a conference on the challenges of climate change in 2008, the Landscape Institute published a position statement highlighting the role of Green Infrastructure as both adaptive and mitigating measures, and this was followed up by a publication on Green infrastructure.

Work by John Handley and colleagues at the Centre for Urban Ecology in Manchester found that a 10% increase in urban greening could help to reduce the urban heat island effect and maintain current temperatures in urban areas in the middle of the century, whereas a 10% decrease in urban greenery could see an increase of up to 8°c due to urban heat island feedback by mid century. The hot summer of 2003 witnessed tens of thousands of additional deaths due to heat stress in cites across Europe. This highlights the need to consider climate change adaptation in urban areas in a holistic manner.

At the end of 2012 the European Environment Agency published an indicator report entitled 'Climate change, impacts and vulnerability in Europe 2012'.

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This publication has been written by Luke Engleback and Philip Jackson, the artwork was created by Simon Beames, Sam Ashdown, Louise Hooper and Luke Engleback at Studio Engleback. The Photographs are by Studio Engleback except where noted. The TSB funded work was led by Radius Regeneration, Daedalus, and Studio Engleback with SDA looking at the architectural interventions and WT Partnership costing internal and external measures. The basis for this publication is our joint report collated from team members by Daedalus shared with the TSB and the global overview and environmental work in Studio Engleback report 265-doc/001 rev C 12.2012.

This book is one of a series of Studio Engleback Publications that address the need for us all to think and behave differently in the light of future climate change, of resource depletion, and environmental degradation. Fundamentally we need to do more with less natural systems need to be reinforced so that they are more resilient to direct and indirect changes that are invariably induced by the way we live, and that appear to be happening at an increasingly rapid rate.

Luke Engleback is an Ecourbanist and Chartered Landscape Architect who currently sits on the South East Design Panel and the South Downs National Park Design Panel, and was a CABE Space Enabler and a former Chairman of the Landscape Foundation. He has been teaching at various schools of architecture for 30years in the UK, Norway, and Estonia and presented papers on aspects of Ecourbanism in Rome, Copenhagen, Tallinn, Flore, Bergen, London, Newcastle and Edinburgh. Studio Engleback started in 1996 becoming a full time entity in January 1999, and has won awards from the Landscape Institute, RIBA, Civic Trust, and Green Apple for work at all levels of intervention from Strategic Environmental Planning, masterplanning, detailed design and communications, as well as for competitions in Australia, Norway, Holland, France, and the UK.

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