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Development of Green Infrastructure for the City: A Holistic Vision towards Sustainable Urbanism

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Abstract - The issues of sustainability in urbanism have been increasingly under discussion and debate in the past few decades. We can also argue that the one approach that has been more successful in achieving sustainable urbanism is the holistic approach. This approach brings in together major dimensions of sustainability, which are also briefly introduced and discussed in this paper. By questioning how we may design more sustainable settlements, this study will look into green infrastructure of the city and will evaluate it as a holistic approach to achieving sustainable design and planning. The paper will particularly focus on the use and multi-use of green spaces in urban environments and how they play major role in achieving sustainability in an urban context. The study will touch on aspects of quality of life, ecological design and climate change, which are relevant to both green infrastructure and sustainable urbanism. The study will initially introduce green infrastructure and its major aspects in sustainable urbanism. It will then explore these aspects through selection of case studies and will finally conclude in how we may decide on design and planning of green spaces as a vision or approach towards sustainable urbanism.

Keywords - Green Infrastructure, Sustainable Urbanism, Green Spaces, Ecological Design, Climate Change

1. Introduction

In order to design more sustainable settlements we must truly understand the meaning of sustainability. The term sustainability was initially defined as delivering '*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*' (Rees & Roseland, 1991). Today, sustainability is irrevocably embedded at the heart of the world's political, statutory, legislative environment, and is now increasingly influencing its financial environment. Increased interest in climate change initially caused a proportional interest in sustainability as a way to battle the changing climate. Now, this interest has increased dramatically as people realize sustainability as an influential quality way of life, thus igniting its potential to be a very marketable product. In this respect, we can elaborate that a successful design is not just defined by how a building, place or environment may appear argue sustainable design and successful design are mutually. Instead, it is about whether it is responsive to context, adaptable, uses resources efficiently and delivers value over its whole life. In addition, the performance of design is a particular measure in identifying its sustainable values. A successful design is not only applicable to the individual structure or space, but also to a collective of structures and spaces like that of a village, town or city. In order to achieve such design in any settlement, we must apply and understand sustainable development that compromises the environmental, socio-cultural and economic dimensions to find the correct balance that flourishes within an urban context.

This paper will explore the concept of green infrastructure and how it can be regarded as a holistic vision towards sustainable urbanism. The paper focuses on green and blue spaces of the urban environments and will exemplify the multi-functional values of such spaces. Having the main pillars of sustainability in mind, the paper will aim to introduce ways in which we can achieve sustainable urbanism through the use of green infrastructure.

1.1. Sustainability in an Urban Context

Every village, town or city works as a system with inextricable links between the key components of consumption and production (Hall & Pfeiffer, 2000). Energy, waste, water, green infrastructure, public space and transport are all essential aspects that need to embrace successful design in order to ensure and maintain a good quality of life (RTPI and CIEEM Report, July 2013) - with the provision of well-designed public services and great access to healthcare, shops and businesses. For this study, the attribute to sustainable settlements that we will discuss in more detail is green infrastructure. We will study the benefits that arise from a settlement adopting a green infrastructure network whilst understand

examples that excel in this sustainable characteristic and realize examples that need to implement a more green approach in sustainable urbanism.

1.2. What is Green Infrastructure?

Green infrastructure is the physical environment within and between our villages, towns and cities. It is the network of green (and blue) elements in and around urban areas, enhancing and maintaining the environmental systems to sustain and maintain quality of life (RTPI and CIEEM Report, July 2013; Town and Country Planning Association and The Wildlife Trusts Report, July 2012). This includes public and private spaces, such as parks, gardens, allotments, cemeteries, trees, green roofs, green facades and natural landscape features such as woodland, grassland, moors and wetlands. With good planning and design, these green assets can help cities to cope with some of the extreme effects of climate change whilst delivering a better quality of life (RTPI and CIEEM Report, July 2013). In challenging urban and climate change pressures, green infrastructure acts as the strategic approach to develop and maximize the sustainable management systems of the city's natural environments (The Mersey Forest Report, January 2013).

In addition, we can refer to green structure as a '*strategically planning and delivered network*' which often includes a wide range of environmental features and green spaces (Town and Country Planning Association Report, September 2008). Thus, there is a major demand for its design and management to operate as a '*multi-functional resource capable of delivering the landscape, ecological services and quality of life*'. This will only benefit the community demands but will also serve the important dimensions of sustainable urban development. In this respect, both design and management of green infrastructure should preserve, improve and develop the distinctiveness features and particular characteristics of an area that reflect on the regional habitats and landscape types (ibid). In this study, the authors elaborate on the significance of green infrastructure in shaping and developing the urban environments.

The green infrastructure challenges the environment sector to deliver a healthy and comprehensive planning approach, linking key priorities of development. It also includes engagement and integration with major sectors of landscape planning, land use planning, management and development (The Mersey Forest Report, January 2013). Also the term 'green infrastructure planning' is derived from the integration of the mentioned disciplines, as a new approach focusing on benefiting the environmental aspect of the environment, mainly the vegetation and open water in and around the city region(The Mersey Forest Report, January 2013). Furthermore, there are perceptible pressures on issues of energy demand, consumption and production growth that have direct and indirect impacts on environmental aspect of development. Thus, as part of RTPI's viewpoint on green infrastructure '*sustainable development must balance economic, social and environmental objectives, make prudent use of natural resources and address the challenges of climate change*'(RTPI and CIEEM Report, July 2013). As a result, the application of green infrastructure in sustainable urbanism has become highly significant in both planning and development. The use of green spaces in urban environments, in particular, is a substantial consideration not only towards making the green urban but also to protect and develop environmental systems that are part of the natural aspect of the city's structure.

2. The Role of Green Infrastructure in Sustainable Urbanism

In this part of the study, the authors illustrate essential aspects of designing green spaces, which are specific to an urban environment. Set aside 'energy' as a major element, the study will focus on design-related aspects in order to achieve a range of multi-functional benefits in sustainable urbanism. Following the three aspects of 'social (or socio-cultural)', 'environmental' and 'economic' in sustainable urbanism, the following aspects are covered in this study:

- Crime
- Local Economy
- Local Climate (Flooding and CO_2 Emissions)
- Biodiversity

In this part of the paper, the authors will express on the relevance and application of green spaces for the above mentioned aspects. Not only limited to these few aspects, green spaces of the urban environments are crucial parts of any city or urban development.

2.1. Green Spaces and Crime

Urban areas have to deal with crime on a day-to-day basis. However, the constant attention and green landscaping of well-used public spaces can reduce crime considerably through natural surveillance. Green areas provide the open space necessary for people to interact visually with the surrounding environment. This in turn creates a visual bond with neighbors to deliver a sense of security within the community. Yet, this is not necessarily a global approach to achieve security in the urban areas. In some particular parts of the world and in the poorer areas in particular, the green landscaping requires careful design and development. The planned green spaces of any urban community need to be well integrated with social and economic attributes of the area. The inclusiveness and effectiveness of design would then allow development of particular measures to reducing crime in the area.

Taking Singapore as an example, it is often referred to as 'The garden city' which is no accident of nature. With the slogan of 'Let's Make Singapore our Garden', it took the officials more than forty years of robust political will and development in sustaining the thriving greenery of the country (The report on 'National Parks – from www.nparks.gov.sg).It is also no accident that Singapore, being one of the greenest cities in the world, adopts one of the

lowest crime rates in the world corroborating the idea that appreciated, aesthetically pleasing, well used public spaces can in fact reduce crime.

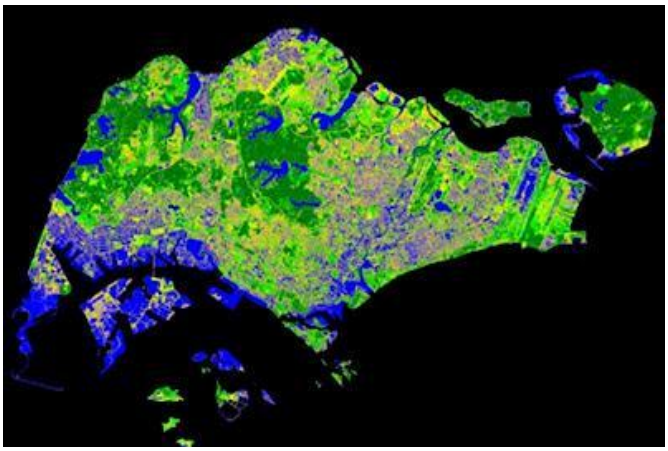

Fig. 1. Map of Singapore's vegetation cover in 2007 (Source: Centre for Remote Imaging, Sensing and Processing (CRISP) and NParks).

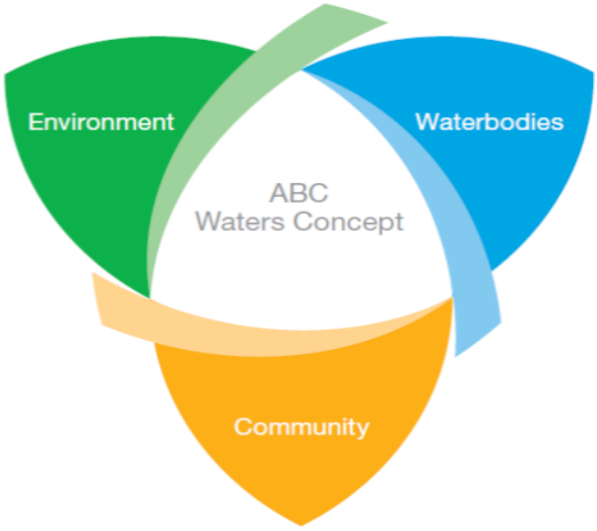

Fig. 2. ABC waters concept (Source: www.pub.gov.sg/abcwaters).

Also the concept of bringing people closer to water and development of 'Active, Beautiful and Clean (ABC)' waters design guidelines are aimed to create more recreational and community spaces promoting better security and surveillance in the urban environments (PUB, Singapore's National Water Agency, Nov 2011). Furthermore, the urban green spaces of Singapore are the essence of the city's structure, focusing on how people will use and interact within these areas. The green infrastructure planning of Singapore (both green spaces and open water areas) is well integrated with social and economic dimensions of the city, allowing for development of multi-functional benefits of the city.

2.2. Green Spaces and Local Economy

It is imperative that green spaces play an important role in the composition of a strong local economy. In the north-west of England, a green infrastructure programme, Natural Economy Northwest (NEN), is driving regeneration and sustainable development (Natural Economy Northwest (NEN), June 2008). The programme reaps its rewards by not only implementing green space that literally produces money in the form of food within allotments, but also by creating and developing green space and specific landscaping that encourages and attracts high value industry to the region. Businesses are attracted to greener spaces as the idea of working in attractive environmental surroundings boost moral within a workforce that in turn produces a higher quality output for the businesses. The influx in businesses would also create employment opportunities for the surrounding area and will not be the only genre to prosper from neighboring green spaces. This also has impacts on increase of real estate and property prices, which also helps to improve the local economy.

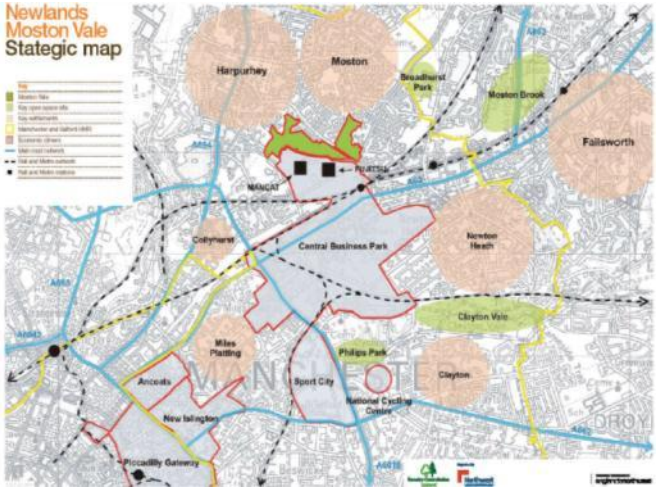

Fig. 3. Strategic Map showing the locations of Moston Vale Community Woodland programme and Central Park (Source: Report commissioned by Natural Economy Northwest (NEN), June 2008).

Fig. 4. Children getting involved in the new local allotments in Moston Valley (Source: Natural Economy Website).

The Natural Economy Northwest (NEN) delivered the Moston Vale Community Woodland programme. From a former landfill site havingmajor pressures of poor quality

environment and anti-social behavior, the site is transformed into '*a community woodland with sporting facilities*…[mainly]…*for the benefit of local business and communities*'(Natural Economy Northwest (NEN), June 2008). Since completion, the project has already seen local investment from Northwest Development Agency and the Manchester-Salford Housing Market Renewal Pathfinder. While house prices are rising as a range of regeneration projects (including the community woodland) have become the boosting value of the area.

2.3. Green Spaces and Local Climate: Flooding

Having looked at how a well-designed green infrastructure can deliver a better quality of life, the authors will now explore more multi-functional benefits of practicing a green approach and observe how it can combat climate change. Flooding is a huge problem in many parts of the world causing damage to homes, crops and lives. With the careful and intelligent planning of landscapes, it is possible to control the effect that flooding has on the built environment. The contours, vegetation and existing buildings of an area must all be assessed before an efficient, responsive flood control programme can be implemented. Hanson's in-house team considered such approach to their flood control programme on the design of Milton Keynes Floodplain. The priorities of the project were to '*increase biodiversity, increase amenity value, ensuring that the new site was accessible to as wide a range of visitors as possible and to reconnect the river to its floodplain*'(Commission for Architecture and Built Environment (CABE), 2011). The new design extracted 700,000 tonnes of gravel from the site to cater for the floodwater whilst hundreds of new trees were planted to aid with flood control. This carefully planned design was a necessity in order to alleviate flooding risks for the surrounding area of Milton Keynes(ibid).

Fig. 5. Milton Keynes Floodplain Forest (Source: National Archives at www.webarchive.nationalarchives.gov.uk, photo taken by Stephen McLaren, accessed via CABE website).

When designing to minimize flooding in an area, the planners or designer need to consider planting more trees to provide more leaves (or areas of leaves). This approach increases the catchment area of rainfallsignificantly. The increased catchment area along with more absorption through roots helps manage surface water runoff to prevent flash floods (ibid). More trees also increase the water storage capacity of an area so that trees can store more tidal and river flood water to reduce the risk of flooding.

2.4. Green Spaces and Local Climate: CO2 Emissions

Of all concerns of the use of green spaces in design, it is important to realize how a well-designed green infrastructure can directly soften the causes of climate change. If green spaces within an urban area can cater for high quality recreational opportunities, then travel could be considerably reduced as people would avoid long journeys by any means of transport from town to town. This mainly occurs as people are considerably satisfied with what there is to offer in their local community. In contrast, if there is a need to travel, the provision of sustainable transport corridors can reduce carbon emissions from vehicles, e.g. eell-designed cycle and pedestrianised routes.

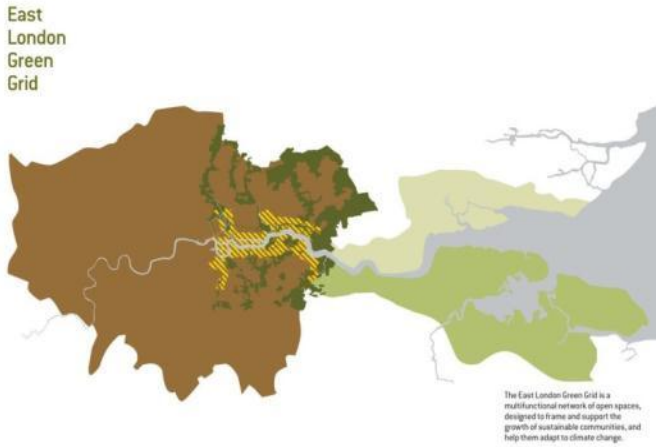

Fig. 6. East London Green Grid as a multi-functional network of open spaces designed to frame and support the growth of sustainable community and help them to adapt to climate change (Source: www.openbuildings.com).

The 'East London Green Grid', one of four sub-regional landscape frameworks developed for the Thames Gateway brings innovative design to sustainable transport corridors. As discussed by Cohen and Rustin (Cohen and Rustin, 2008),'*It is one of the first spatial frameworks of its kind to use a landscape and human-centred approach to green infrastructure.*' It is designed to respond to two key issues – climate change and future development. The framework spans over new and existing green spaces. The programme emphasises upon connectivity, with green corridors linking town centres and transport nodes to major employment and residential sites. River corridors also have a critical role to play as they offer natural links to the green belt. As well as providing great recreational opportunities, biodiversity and flood protection, the Green Grid design focuses on creating naturalistic transport corridors that encourage a minimal carbon footprint during travel (ibid).

Fig. 7. Vision for Mills Meads, an operational site for Thames Water, incorporating some of London's strategic pumping stations, that is not currently accessible to the public (Source: 5th Studio / Design for London)

In addition, Management of green spaces allow for the development of natural production lines such as, farming. Growing crops that supply biomass or biofuels in order to directly replace the use of fossil fuels allows us to continue with a demanding modern day lifestyle without diminishing our natural resources. Furthermore, the use of timber (a renewable material) in design should be a necessity as it replaces less sustainable materials such as steel and concrete due to a lower carbon embodiment throughout the production line. On a smaller scale, the production of food in local communities reduces the amount of food miles, thus reducing carbon dioxide emissions. This does not mean that every person has to sacrifice time and turn into farming in their own backyard; however, it may mean that a green space could be designed for an individual within a community, who is likely to have volunteered in order to provide for neighbors. The green space would incorporate a range of vegetation (fruits and vegetables) to remove carbon dioxide from our atmosphere by photosynthesis (Seely et al., 2002). The green spaces should also be maximized and take full advantage of exposed soil to achieve maximum carbon storage and sequestration (Bruce et al., 1999; Post and Kwon, 2000).

2.5. Green Spaces and Biodiversity

Biodiversity is a rewarding attribute to the design of a new green space. Action plans can be integrated into the design of green spaces by identifying the key species of an area and presenting strategies designed to improve and increase habitat for selected species, hoping to increase their numbers in that area. In order to provide the correct habitat for wildlife, it is important that the vegetation selected for the green spaces is indigenous to that area.

Such consideration into planning and design ensures that a beneficial contribution to the local ecosystems is achieved (Town and Country Planning Association and The Wildlife Trusts Report, July 2012). All of the case studies mentioned in this study have adhered to ecosystems within their areas to create the right biodiversity. Furthermore, we can argue that vegetation is vital within a city as it not only provides shelter and protection for humans during extreme weather, but also provides magnificent habitats, corridors and a more permeable landscape to help wildlife adapt to climate change.

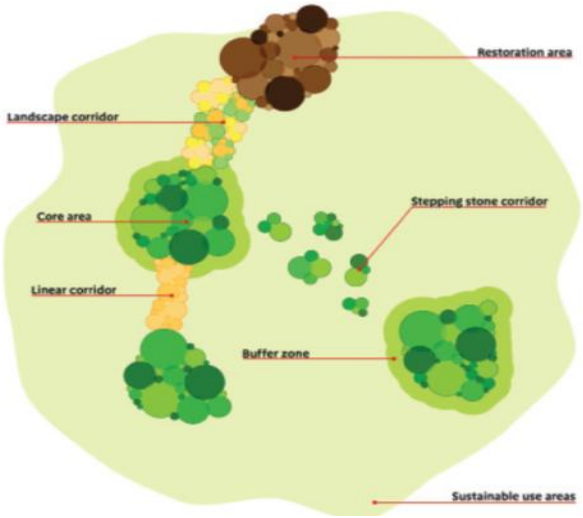

Fig. 8. The components of ecological networks (Source: Natural England from report on'good practice guidance for green infrastructure and biodiversity', July 2012)

3. Discussions: Green Infrastructure and Healthier Living Style

A well-designed green infrastructure promotes the option of adopting a healthier lifestyle. If we look at council estates in Sheffield, we can see that the majority may adopt a green infrastructure; however, the infrastructure they adopt is extremely poor. The green spaces are often derelict, rectangular patches of grass with a few randomly dotted trees that together serve no appeal or purpose to a public in desperate need for change. One of the significant examples is the Park Hill Estates in Sheffield, which has been under criticism for many years.

Fig. 9. The original status of Park Hill Estate Flats in Sheffield, UK with randomly dotted trees and landscape (Source: Urban Realm Magazine, September 2004)

In 1996, The Guardian wrote that the Manor and Castle Green estates in Sheffield, home to some 20,000 people, were considered as the worst estates in Britain (The Guardian Newspaper on September 14, 1996). The estates contained some 600 hectares of mixed-use open space, which had unbelievable potential for a well-designed green infrastructure to be implemented. The refined design proved and still is proving to be a success not just within the local community, but also throughout the whole of Sheffield. The first priority was to address basic issues of cleanliness, access and perceptions of safety. As the project developed, new features and facilities, such as, formal and naturalistic play areas, art, and different planting approaches were implemented to great effect. The green spaces across the estate are now being used to promote healthier lifestyles with unprecedented sustainable designs such as:

- Sustainable urban drainage – a more natural method to control rainwater and surface runoff
- Use of exotic meadows – a scenic route through the estate with the provision of healthier air
- Naturalistic play grounds – natural fallen trees, logs and lakes provide the ideal area for children
- Green waste processing – waste is recycled on site without polluting air or nearby rivers or lakes

Fig.10. Pictorial Meadows seed display in social housing context in Shirecliffe, Sheffield, UK (Source: Green Estate Ltd., Extracted from CABE website)

The vegetation itself that forms the make-up for a green infrastructure is vital for embracing a healthier lifestyle. Urban spaces are often warmer than rural spaces as a result of poor design and the issues of urban heat island effect. Cities are warmer than surrounding areas because heat is stored within concrete and tarmac, a problem compounded by traffic and poor air circulation between tall buildings. Dark colored building materials that retain a high thermal mass (e.g. concrete) are major factor contributing to urban heat island effect. The introduction of vegetation into the area allows for evaporative cooling through evapo-transpiration. The evaporation that takes place is an endothermic process, which draws heat out of the atmosphere, cooling the surrounding area. Trees and plants also provide natural shading and formulate corridors for cooler air to flow into urban areas as well as filtering polluted air by absorbing carbon dioxide through photosynthesis (Sandstrom, 2008; Town and Country Planning Association and The Wildlife Trusts Report, July 2012).

Furthermore, strategic plans for green routes, like the use of exotic meadows in Shirecliffe, present the public with safe, easily accessible areas for walking and cycling. Large flat green spaces, like the naturalistic playgrounds in Manor estate, are also ideal for social events such as circuses, fun-fairs and concerts which greatly encourage community integration. The existence of these well-designed green spaces within a settlement is fundamental to reducing physical and mental health problems. People have the opportunity to practice a range of physical and social activities whilst experience the enjoyment of open space and nature.

3.1. Achieving Sustainable Urbanism through the Use of Green Infrastructure

The design of green spaces in and adjacent to buildings should be integrated into the design process right from the beginning. As well as delivering natural aesthetic appeal, the main function of green spaces in buildings is to regulate temperatures and provide a comfortable environment to live or work in. The vegetation integrated into buildings can create cooler microclimates and, therefore, reduces the need to cool buildings with the use of air-conditioning. Less air-conditioning helps use less energy and diminishes the amount of carbon dioxide forced into the atmosphere. The authors have briefly mentioned the ‘urban heat island effect’ and how plants can be used for shading in Healthier Lifestyle. Now we will look at two great examples that demonstrate how the design of green spaces can mitigate some of the problems in their immediate urban context.

Fig. 11. The High Line in the urban context of New York (Source: www.ludiccity.com)

Chicago and New York are both cities that have neglected their environmental surroundings in the past with copious

primitive skyscrapers that ignore the changing climate. There are also limited green spaces open to the public throughout the cities. However, the introduction of high-rise green spaces and eco-skyscrapers are gradually being introduced into both cities. Eco-skyscrapers can provide comforting working environments for people by having integrated systems to collect and use rainwater, naturally ventilate and shade spaces. As two successful examples, New York's 'The High Line' and Chicago's 'City Hall' epitomize great climatic responsive design in an urban environment.

Fig. 12. City Hall roof gardens, Chicago (Source: SundayBell website on 'top five epic rooftop gardens', May 17, 2013)

'The High Line' is a '*public park built on a defunct railway that runs 30 feet above Manhattan between 10th and 11th Avenues*' (The New York Times, on June 9, 2009). Since opening in June 2009, nearly 2 million people have visited this public park. The park is currently expanding but meanwhile serves as a beautiful green intervention that weaves through old and new buildings throughout Manhattan, providing an invaluable sustainable corridor with great access to nature. Similarly, Chicago's 'City Hall' roof provides a small green oasis in the middle of a busy city. The design has allowed for future potential connections to neighboring buildings, while naturally insulating the building in cold winters and prohibiting heat to penetrate in hot summers. Both landscaping projects are assets to their urban neighbors as they turn unpleasant unused high-rise spaces into luxuriant green spaces that boast stunning views across each city.

Through the brief analysis of various case studies, this paper elaborates on the multi-functional attribute of green spaces as the main part of the green infrastructure of the urban environments. The city and any urban development require including the environmental consideration in design and planning in'*enabling the achievement of a sustainable and sustaining urban development*' (Cheshmehzangi et al., 2010). The given examples in this study demonstrate various implications of using green spaces in urbanism. To conclude, it is important to consider the role of green infrastructure as a holistic vision, bringing in together social (or socio-cultural), environmental and economic aspects of sustainability.

4. Conclusions

Refining the design of green infrastructure within urban areas is a way of getting more out our green spaces, making them hugely efficient and valuable assets by bringing many benefits to residents. Green spaces are the life support systems of our villages, towns and cities. It is this green infrastructure that makes crowded urban areas livable and urban life environmentally, economically and socially viable. Areas of multiple deprivation often contain the most neglected and under-used areas of public space. In Sheffield's case, we have learnt that the rehabilitation of a single park in a deprived area can act as a catalyst to rehabilitate the entire community, simultaneously influencing neighboring communities and setting an example for a larger audience. Qualities within the topics discussed all interlink with one another demonstrating the multi-functional benefits that green spaces have to offer.

Finally, we can conclude green infrastructure is just one of the many indicators used to measure the environmental, socio-cultural and economic dimensions within an urban context. However, if specific, sustainable design of a green infrastructure network that understands the needs for an individual place can be put into practice, then it will play an essential role in achieving sustainable urbanism by helping people to pursuit happiness and maintain a good quality of life.

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